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TRANSCRIPT OF RECORD.

SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1884.

No. 141.

THE ELECTRIC RAILROAD SIGNAL COMPANY, COMPOSED OF FRANK L. POPE, STEPHEN C. HENDRICKSON, AND JAMES D. LINCOLN, SURVIVING PARTNERS, APPELLANT,

vs.

THE HALL RAILWAY SIGNAL COMPANY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE DISTRICT OF CONNECTICUT.

FILED OCTOBER 26, 1881.

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1 & 2 THE ELECTRIC RAILROAD SIGNAL CO.
vs.
THE HALL RAILWAY SIGNAL CO. } In Equity.

To the Honorable Supreme Court of the United States:

The appeal of Frank L. Pope, Stephen C. Hendrickson, and James D. Lincoln, surviving partners of the said firm of the Electric Railroad Signal Company, the above-named complainant and appellant, respectfully showeth:

That on or about the 3d day of September, 1875, the above-named complainants (with whom James N. Ashley, since decease, was then joined as co-complainant) filed their bill in the circuit court of the United States for the district of Connecticut against the above-named defendant, in which bill said complainant alleged that prior to July 1, 1873, said Frank L. Pope was the true, original, and first inventor of a new and useful improvement in circuits for electric railroad signals, which improvement was not known or used by others before the invention or discovery thereof by said Pope,
3 and had not been, at the time of his application for letters patent thereon, in public use or on sale with his consent or allowance for more than two years prior to his said application.

That said Pope made application to the Commissioner of Patents of the United States for letters patent thereon, whereupon such proceedings were had that letters patent of the United States No. 140,536, dated July 1st, 1873, were duly issued to him in due form of law, as in said bill is fully and at large set forth.

That on July 1, 1875, said Pope duly conveyed to "The Electric Railroad Signal Co." aforesaid, a copartnership then consisting of your petitioners and said Ashley, all his interest in said patent and in said invention with the rights growing thereout, as is also set forth at large in said bill.

That said Electric Railroad Signal Co. had ever since been, and then was, sole owner of said patent.

That said improvement and invention had theretofore been in the exclusive possession of said Electic Railroad Signal Co., and had been of profit and value to said Co., and that but for the in-
4 fringement in said bill complained of would then have been in its undisturbed possession and enjoyment.

That said defendants, without right and in violation of petitioners' rights, after said 1st day of July, A. D. 1873, had made, used, vended, and put in practice, and was still making, using, vending, and putting in practice, in large numbers of railroads (and petitioners prayed that defendants might discover and set forth the number) the improvement and invention, or a material part thereof, set forth and patented in and by said letters patent, at Meriden, in said district, and at other places in the United States, thereby infringing the right of said petitioners.

And said petitioners, in and by said bill, prayed that defendant should make full and perfect answer, and for decree that they pay over to said petitioners all gains and profits from unlawful using or

vending of said improvement, and for perpetual injunction, and for such other relief as equity should require.

That the said defendants appeared to said bill and put in their answer thereto, in which the principal and material allegations of said bill were denied (except the granting and issuance to said Pope of the patent, as set forth by the petitioners in said bill); and it is alleged that one Thomas A. Hall was first inventor of said improvements; that the specifications of said Pope were insufficient; that Pope's invention had been in public use more than two years before his application for a patent; that said improvements were known to parties other than said Hall and said Pope before said Pope's said application for a patent, and that the combination and arrangement set forth by said Pope in said patent is not an invention, and therefore not patentable; and the answer having been replied to, the cause came on to be heard before the Hon. N. Shipman, judge of the district court of the district of Connecticut, and, upon due hearing of the parties and their evidence, and after argument of counsel, decree dismissing the bill of said petitioners, with costs to the defendants, was prepared and entered by said judge, to wit, on the 26th day of April, 1881, but was suspended by subsequent proceedings in the cause, and took effect and became final on the 3d day of October, A. D. 1881.

Wherefore this appellant appeals from the whole of said decree of said circuit court of the United States, and respectfully prays that the decree of the said circuit court and the bill, answer, pleadings, depositions, evidence, and proceedings in the said cause may be sent to the Supreme Court of the United States without delay, and that the said Supreme Court will proceed to hear the said cause anew, and that the said decree of the circuit court, and every part thereof, may be reversed and such other decree may thereupon be made as to said Supreme Court shall seem just.

And the appellant files herewith good and sufficient bond, which he prays may be accepted as sufficient security to the defendant for damages and costs, and as supersedeas of the execution of said decree pending this appeal.

Dated at Hartford, Connecticut, this 5th day of October, A. D. 1881.

THE ELECTRIC RAILROAD SIGNAL COMPANY,
By C. E. PERKINS &
F. CHAMBERLIN,
Solicitors & of Counsel for said Appellants.

Supreme Court of the United States.

THE ELECTRIC RAILROAD SIGNAL CO.
vs.
THE HALL RAILWAY SIGNAL CO. } In Equity.

Know all men by these presents, that I, Charles E. Perkins, of Hartford, in the State of Connecticut, are held and firmly bound unto the Hall Railway Signal Co., of Meriden, Connecticut, in the

sum of two thousand dollars, to be paid to the said Hall Railway Signal Co. and its assigns, to which payment, well and truly to be made, I bind myself and my heirs, executors, and administrators firmly by these presents. Sealed with my seal. Dated this fifth day of October, A. D. 1881.

Whereas Frank L. Pope, Stephen C. Hendrickson, and James D. Lincoln, surviving partners of the said firm of The Electric Railroad Signal Co., complainants above named, have taken an appeal to the Supreme Court of the United States to reverse the decree rendered in the above-entitled action by the circuit court of the United States for the district of Connecticut:

8 Now, therefore, the condition of this obligation is such that if said Electric Railroad Signal Company shall prosecute its said appeal to effect, and answer all costs and damages, if it shall fail to make its plea good, then this obligation shall be void; otherwise to remain in full force and virtue.

CHAS. E. PERKINS. [SEAL.]

This bond is approved Oct. 5th, 1881.

N. SHIPMAN, *Judge.*

9 By the Honorable Nathaniel Shipman, judge of the district court of the United States for the district of Connecticut, to the Hall Railway Signal Co.:

Whereas The Electric Railroad Signal Co. has lately appealed to the Supreme Court of the United States from a decree lately rendered in the circuit court of the United States for the district of Connecticut, made in favor of you, the said Hall Railway Signal Co., and has filed the security required by law. You are therefore hereby cited to appear before the said Supreme Court, at the city of Washington, on the 24th day of October, A. D. 1881, to do and receive what may appertain to justice to be done in the premises.

Given under my hand, at the city of Hartford, in the district of Connecticut, in the second circuit, the 5th day of October, in the year of our Lord one thousand eight hundred and eighty-one.

N. SHIPMAN,
District Judge.

NEW HAVEN, CONN., *Oct. 7th*, A. D. 1881.

Due and legal service of the within citation is acknowledged.

SIMEON E. BALDWIN,
Attorney for Appellees.

10 Be it remembered that on the 3rd day of September, 1875, there was filed in court a bill in equity in the words and figures following, viz:

U. S. Circuit Court, District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL COMPANY
vs.
THE HALL RAILWAY SIGNAL COMPANY. } In Equity.

Complainants' Bill.

To the honorable the judges of the circuit court of the United States for the district of Connecticut, in chancery sitting:

Frank L. Pope, of Elizabeth, in the county of Union, State of New Jersey, and a citizen of said State, and Stephen C. Hendrickson, of the city of Brooklyn, county of Kings and State of New York, a citizen of said State, and Jas. N. Ashley and Jas. D. Lincoln, both of the city of Jersey City, county of Hudson and State of New Jersey, and both citizens of said State, all being copartners and doing business together under the firm name and style of "The Electric Railroad Signal Company," having its office and principal place of business in the city, county, and State of New York, bring this their bill of complaint against "The Hall Railway Signal Co.," a corporation organized under the laws of the State of Connecticut, and located and having its principal place of business at the city of
11 Meriden, county of New Haven, in the said State of Connecticut, and therefore your orators complain and say:

That prior to July 1, A. D. 1873, Frank L. Pope aforesaid, a citizen of the United States, was the true, original, and first inventor of a certain new and useful improvement in circuits for electric railroad signals, which said improvement was not known or used by others before the invention or discovery thereof by said Frank L. Pope, and had not been, at the time of his application for letters patent thereon as hereinafter mentioned, in public use or on sale, with his consent or allowance, for more than two years prior to his said application.

That said Frank L. Pope, being, as aforesaid, the true, original, and first inventor of said improvement pertaining to railroad signals, made an application to the Commissioner of Patents of the United States for letters patent thereon, in due form of law, whereupon such due legal proceedings were had that letters patent of the United States No. 140,536, dated the 1st day of July, A. D. 1873, were issued to said Frank L. Pope, in due form of law, under the seal of the United States Patent Office, signed by the then Secretary of the Interior and countersigned by the then Commissioner of Patents, whereby was granted and secured to the said Frank L. Pope, his executors, administrators, and assigns, or intended so to be, for the term of seventeen years from and after the day of the date of said letters patent, the full and exclusive right and liberty of making, using, and vending to others to be used the said improvement pertaining to railroad signals as set forth in said letters patent, and a description whereof is given in the words of said inventor in a schedule in writing, accompanied by drawings and references thereto, duly annexed to said letters patent, when the same was issued and made a part thereof, and by virtue of which said Pope became and was the

sole owner of the rights and privileges granted and secured, or intended so to be, in and by said letters patent, as by said original letters patent or a duly authenticated copy thereof, here in court ready to be produced if required, will fully appear.

12 And your orators further show unto your honors, that by an assignment in writing, signed and sealed by said Frank L. Pope, dated the 1st day of July, A. D. 1875, said Pope, for a valuable consideration, conveyed to the Electric Railroad Signal Company, a copartnership formed as aforesaid, all his right, title, and interest in and to the said invention secured by said letters patent in and for the whole United States of America, with the exclusive right and license to make, use, and vend said inventions and improvements pertaining to railroad signals during the unexpired term of said letters patent, as by said original assignment, or a duly authenticated copy thereof, here in court ready to be shown, if required, will more fully appear.

And your orators have ever since been, and now are, the sole owners of said letters patent.

And your orators further show unto your honors that said improvement and invention, patented and assigned as aforesaid, has hitherto been in the exclusive possession of your orators, and has hitherto been of great profit and value to your orators, and, but for the infringement hereinafter complained of, your orators would now be in the undisturbed possession and enjoyment of the exclusive privileges secured by the said letters patent.

Yet the said defendants, as your orators are informed and believe, well knowing the premises, but contriving to injure your orators, and without their consent and allowance, and without right, and in violation of your orators' said rights, have, at said city of Meriden, and within said district of Connecticut, and at other places within the United States, to wit, upon the railroads in the States of Massachusetts and New York, between Lowell and Boston, Somerville and Ipswich, and Boston and Albany, in said States, and since the 1st day of July, A. D. 1875, made, used, vended, and put in practice, and are still making, using, and vending to others to be used, and putting in practice upon large numbers of railroads, but how

13 many your orators cannot state, but pray that the defendants may discover and set forth the number, containing substantially the improvement and invention, or a material part thereof, set forth and patented in and by said letters patent, at said city of Meriden, within said district of Connecticut, and at other places within the United States, and thereby the said defendants have infringed, and still do infringe, and your orators fear that in future they will infringe, upon the exclusive rights and privileges secured to your orators as aforesaid.

To the end, therefore, that the said defendants may, if they can, show cause why your orators should not have the relief herein prayed for, and may, according to the best and utmost of their knowledge, remembrance, information, and belief, full, true, direct, and perfect answer make to all and singular the premises, and that they may be decreed to account for and pay over to your orators all gains

and profits realized by them from the unlawful making, using, putting in practice, or vending the improvement vested in your orators as aforesaid, and may also be decreed to pay to your orators such damages as your orators have thereby sustained, and may be perpetually restrained, by an injunction to be issued out of the honorable court, from making, vending, using, constructing, or putting in practice the invention and improvement, or any material or substantial part thereof, set forth and claimed in said letters patent belonging to your orators as aforesaid.

And that your orators may have such other or such further relief as equity may require and to your honors may seem meet.

May it please your honors to grant unto your orators not only a writ of injunction conformably to the prayer of this writ, but also a writ of subpœna directed to said defendants, The Hall Railroad Signal Co., commanding them at a certain time, and under a certain penalty, to appear before your honors in this court, then and there to answer unto this bill of complaint, and to abide by and perform such decree as this honorable court shall make in the premises.

14 May it please your honors to grant unto your orators not only the writ of injunction, conformably to the prayer of this bill, but also the writ for a provisional or temporary injunction, issuing out of and under the seal of this honorable court, enjoining and restraining the said defendants to the same purport and effect, as is hereinafter prayed, with regard to such perpetual injunction.

And your orators will ever pray.

THE ELECTRIC RAILROAD SIGNAL CO.,
By FRANK L. POPE,
One of the aforesaid Copartners.

[Oath as to truth of matters herein.]

Date of filing bill, September 3, 1875.

15 And on the 3d day of September, 1875, Messrs. Chamberlin, Hall & White entered their appearance for the complainant, and on the 16th day of September, 1875, Simeon E. Baldwin, Esq., appeared for the defendant. And on the 30th day of October, 1875, defendant filed answer in the words and figures following, viz:

16 Circuit Court of the United States, District of Connecticut.

FRANK L. POPE, STEPHEN C. HENDRICKSON, JAMES N. ASHLEY, AND JAMES D. LINCOLN
vs.
THE HALL RAILWAY SIGNAL COMPANY.
} In Equity.

The answer of the Hall Railway Signal Company, defendants, to the bill of complaint of Frank L. Pope, Stephen C. Hendrickson, James W. Ashley, and James D. Lincoln, doing business as the Electric Railroad Signal Company, complainants.

These defendants now and at all times hereafter saving and re-

serving to themselves all manner of benefit and advantage of exception that can or may be had or taken to the many errors, insufficiencies, and imperfections in the said bill contained, for answer thereto, or to so much thereof as they are advised it is material or necessary for them to make answer unto, answering say:

That they do not know, and are not informed, save by said bill, whether or not the said complainants reside and are citizens and do business as copartners as stated in said bill, and leave the complainants to make such proof thereof as they may be advised is material.

And these defendants, further answering, admit that they are a corporation organized and doing business as stated in said bill.

And these defendants, further answering, on information
17 and belief admit that letters patent of the United States No. 140,536 were granted on the first day of July, 1873, to said Frank L. Pope for an alleged improvement in circuits for electric railroad signals, but whether or not said patent was applied for, and issued, as stated in said bill of complaint, these defendants do not know, and are not informed, save by said bill, and leave the complainants to make such proof thereof as they may be advised is material.

And these defendants, further answering, say that they do not know, and are not informed, save by said bill, whether or not the said Pope, by an assignment in writing, signed and sealed by him, dated the first day of July, 1875, for a valuable consideration, conveyed to the Electric Railroad Signal Company all his right, title, and interest in and to his said alleged invention in and for the whole United States of America, with the exclusive right and license to make, use, and vend said alleged invention pertaining to railroad signals, or whether or not the complainants are the sole owners of said letters patent, or whether or not the said patent has hitherto been in the exclusive possession of the complainants, and leave the complainants to make such proof thereof as they may be advised is material; but these defendants, on information and belief, deny that said alleged invention has been of great profit and value to the complainants, and deny that they, the said defendants, have ever infringed upon any legal rights of the complainants.

And these defendants, further answering, on information and belief deny that, by virtue of any such patent and assignment as mentioned in the said bill of complaint, said complainants became or ever were legally possessed of or vested with any exclusive right to make, use, or sell, in the United States or elsewhere, the alleged invention patented by the said letters patent.

And these defendants, further answering, on information and belief say that the description of the alleged invention, as set forth in the specification annexed to said letters patent No 140,526 is incomplete and ambiguous, and that the said specification does not
18 show the method of making and using the said alleged invention in such full, clear, and exact terms as to enable any person skilled in the art or science to which it pertains to make, con-

struct, and use the same, and that, therefore, the said letters patent are void.

And these defendants say that they have never made, used, or sold, or caused to be made, used, or sold, any railroad signals, or other apparatus, the right to which was or is secured by the said letters patent in said bill mentioned, or which are any infringement on any legal rights of said complainants as alleged in said bill.

And these defendants, further answering, on information and belief deny that the said Frank L. Pope was the true, original, and first inventor of the invention or thing described and patented, or of any substantial and material part thereof, claimed as new in the said letters patent No. 140,536, so granted to said Pope on the first day of July, 1873, and these defendants, on like information and belief, allege that the said invention or thing described in said letters patent, or material and substantial parts thereof, had been anterior to any supposed discovery or invention thereof by said Frank L. Pope known to and used by the following persons, to wit: Thomas Shepard Hall, who now resides at West Meriden, Connecticut, and who had such prior knowledge of and used the same at said West Meriden, and at or near Stamford, Connecticut, and at New Haven, Connecticut, and in and upon the line of the Hartford & New Haven, the New York & New Haven, the New York & Harlem, the Eastern, the Boston & Albany, the Flushing & North Side railroads, and Elery P. Warner and John B. Odell, both of Galesburg, Illinois, who had such prior knowledge thereof, and used said invention at said Galesburg, and by others at present unknown to these defendants, but who, when known, they pray leave to name and refer to in their answer.

And these defendants, further answering, on information and belief say that the said invention and discovery, described and claimed in said patent as the invention and discovery of the said Pope, was in fact invented and discovered by, and the same principle
19 and thing so patented to said Pope were known to and had been, previously to the alleged invention thereof by said Pope, combined by the said Thomas Shepard Hall, who then resided at Stamford, in the State of Connecticut, and who, at the time the said patent was obtained by the said Pope, was using reasonable diligence in adopting and perfecting his the said Hall's invention and discovery, and that the said Pope surreptitiously and unjustly obtained the said patent for the invention and discovery patented in the said letters patent No. 140,536, and that the said Pope, by some means unknown to the defendants, obtained knowledge of the said invention of the said Hall, and unjustly and wrongfully took and appropriated and embodied the same, or part thereof, in his application for said letters patent No. 140,536, knowing that the same was the invention of said Hall, and that the same was not the invention of him, the said Pope; and that therefore the said letters patent are void.

And these defendants, further answering, on belief and information say that the said invention and discovery and the same principle and combination, or substantial and material parts thereof, pat-

ented in and by the said letters patent No. 140,536, on which this suit is brought, were patented on the 15th day of August, 1871, by letters patent No. 2150, granted by the Government of Great Britain to William Robert Lake, which patent was sealed the 29th September, 1871, and that the said invention and discovery, or substantial and material parts thereof, are fully described and set forth in said British letters patent and the specification and drawings pertaining thereto, and that the said specification and drawings pertaining to said British letters patent were printed and published in the Great Seal Patent Office, London, in the year 1871, and publicly circulated prior to the supposed invention and discovery by said Pope of his said alleged invention, and that copies of said printed publication are to be found in the library of the United States Patent Office and in the Astor Library, New York, and, as these defendants are informed and believe, in other public libraries and places in the United States.

And these defendants, further answering, on information and belief say that the said invention and discovery and the same principle and combination, or substantial and material parts thereof, patented in and by said patent No. 140,536, are also set forth, described, and contained in the following letters patent, to wit: Letters patent of the United States, No. 130,612, dated August 20, 1872, granted to E. P. Warner and John B. Odell, for improvements in Electric Railway Signal; letters patent of the United States, No. 118,606, dated August 29th, 1871, granted to said Thomas S. Hall for improvement in electro magnetic signal apparatus for railroads; British letters patent, dated February 10th, 1855, No. 314, granted to George Henry Ingolls for improvement in telegraph for railways; British letters patent, granted February 7, 1854, No. 305, to Urbain Bianchi for electric signalling apparatus; British letters patent, dated September 11, 1860, No. 2194, granted to Jean Deuechand and Joseph Capa for indicating the relative positions of trains and railways; British letters patent, dated May 23d, 1863, No. 1301, granted to R. A. Brooman for indicating the position of trains upon railways; British letters patent upon provisional specification, dated November, 1861, No. 2807, granted to William Clark for railway signal apparatus; British letters patent, dated April 7th, 1858, No. 747, granted to George William Baker for signal apparatus for railways; and that the said British letters patent and provisional specification are printed and published by the Great Seal Patent Office, and that printed copies thereof are found in the library of the United States Patent Office, the Astor Library, New York, and in other public libraries and places in the United States, and that said alleged invention is also described in other patents and printed publications at present unknown to these defendants, but which when known to them they pray leave to include in this their answer.

And these defendants, further answering on information and belief, say that the alleged invention and discovery, and the same principle and combination and substantial and material parts thereof, patented in said patent No. 140,536, had been in pub-

21 lic use or on sale in this country for more than two years before the said Pope made application for said letters patent No. 140,536, and that such public use or sale was made by the said Thomas Shepard Hall on the lines of the Hartford & New Haven, the New York & New Haven, the New York & Harlem, and the Flushing & North Side railroads in the United States and under his letters patent aforesaid.

And these defendants, further answering on information and belief, allege and will insist that the construction and arrangement of a battery B, positive and negative conductors C and Z, two or more electro magnets M M^1, M^2 for actuating signals, and two or more circuit closers A, A^1, A^2, placed at intervals along the line of a railroad substantially as specified in said patent No. 140,536, and the construction and arrangement of a battery B, positive and negative conductors C, Z, two or more electro-magnets M, M^1, M^2, for releasing or reversing signals, and two or more circuit closers A^1, A^2, placed at intervals along the line of a railroad, substantially as is specified in patent No. 140,536, are not an invention or inventions within the meaning and intent of the patent law, and cannot legally be the subject-matter of letters patent, and that the said constructions and arrangements do not constitute legitimate or practical combinations; and that the said letters patent No. 140,536 so granted to said Pope, in so far as it covers or embraces, or claims or purports to cover or embrace or claim any such applications or combinations, are wholly null and void.

And these defendants, further answering, admit that they have made and put up railroad signals at Meriden and elsewhere in Connecticut, and in the State of Massachusetts and New York since the first day of July, 1873; but they deny that any of such railroad signals or apparatus pertaining thereto so made, put up, or sold by them have been made according to, or contain or use any invention or improvement of or belonging to said complainants, and these defendants further allege and will insist and maintain that they have had and have full and lawful right and power to make and sell railroad signals constructed and operated like those heretofore made, used, and sold by them.

22 And these defendants, further answering, say that all the railroad signals so made and sold by them have been made rightfully and under and in accordance with letters patent of the United States, Reissue No. 3859, dated March 1, 1870; No. 90743 and No. 90744, dated June 1, 1869; Reissue No. 4493, dated August 1, 1871; No. 103,174, dated May 17, 1870; No. 103,875, dated June 7, 1870; No. 105,447, dated July 19, 1870; No. 113,425, dated April 4, 1871; No. 118,606, dated August 29, 1871; No. 119,137, dated September 19, 1871; No. 121,870, dated December 12, 1871; No. 150,030, dated April 21, 1874, and No. 167,570, dated July 13, 1875, and letters patent No. 143,935, granted October 21, 1873, to G. H. Snow.

And these defendants, further answering, say that for the purpose of showing the state of the art before and at the time of the alleged invention of said pope, they will put in evidence, and use on the

hearing of this cause, in addition to the American and British letters patent above mentioned, the following letters patent granted by the Government of Great Britain, and severally printed and published at the dates thereof, and found in the Patent Office and Astor Library, and in public libraries in Boston and Philadelphia and elsewhere, to wit, letters patent No. 2150, above mentioned, granted August 15, 1871, to William Robert Lake; No. 2574, granted in the year 1862 to one J. Imray; No. 747, granted in the year 1858 to one Raker; No. 2660, granted in the year 1860 to one W. Bull; No. 13906, granted in the year 1852 to one E. Tyer; No. 447, granted in the year 1868 to Barnes and Handcock, on a provisional specification printed and published as above stated, and found in said Patent Office and Astor Libraries.

And these defendants, further answering, deny that they have ever contrived to injure said complainants, or to deprive them of any profits or benefits whatever.

And these defendants pray the same benefit of the facts and things herein set forth as if for the same reason thereof the said bill had been demurred to where a demurrer would have been proper, and the same benefit thereof as if they had been specially pleaded to the said bill.

23 And these defendants submit to this honorable court that said complainants have no right to any further answer to said bill or any part thereof than is herein above contained, and no right to any injunction, account, damages, or other relief prayed for in said bill, and these defendants pray to be hence dismissed with their reasonable costs and charges in this behalf most wrongfully sustained.

THE HALL RAILWAY SIGNAL CO.,
By ALVAH W. HALL, *Secretary.*

SIMEON E. BALDWIN, *Solicitor for Defendants.*
J. VAN SANTVOORD, *Of Counsel.*

DISTRICT OF CONNECTICUT, } ss:
City of New Haven, }

On this 30th day of October, 1875, before me personally appeared Alvah W. Hall, who, being by me duly sworn, says: That he is the secretary of the above-named defendants; that he has heard read the foregoing answer subscribed by him, and knows the contents thereof; and that the same is true of his own knowledge, except as to those matters therein stated on information and belief, and as to those matters he believes it to be true.

A. W. HALL.

Subscribed and sworn to before me.

SAMUEL L. BRONSON,
U. S. Commissioner.

And on the 3d day of June, 1876, the complainant filed its replication to said answer, in the words and figures following, viz:

24 United States Circuit Court, District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL COMPANY
v.
THE HALL RAILWAY SIGNAL COMPANY } In Equity.

The replication of the above-named complainants, The Electric Railroad Signal Company to the answer of The Hall Railway Signal Company, respondents.

The repliants, saving and reserving to themselves all and all manner of advantage and exception to the manifold insufficiencies of said answer, for replication thereto, saith: That they will aver, maintain and prove their said bill to be true and sufficient in the law to be answered unto, and that the said answer of the said defendant is uncertain, untrue, and insufficient to be replied unto by these repliants, without this, that any other matter or thing whatsoever in the said answer contained material or effectual in the law to be replied unto, confessed and avoided, traversed or denied, is true. All which matters and things this repliant is and will be ready to aver and prove, as this honorable court shall direct, and humbly prays as by said bill is already prayed

THE ELECTRIC R. R. SIGNAL CO.,
By CHAMBERLIN & PERKINS, *Att'ys.*

25 And the evidence for the complainants as filed in the case is as follows, viz:

United States Circuit Court, District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL COMPANY
vs.
THE HALL RAILWAY SIGNAL COMPANY. } In Equity.

Complainants' Evidence,

Taken before E. E. Marvin, special examiner, at Hartford, Conn., Nov. 9, 1875.

Messrs. Chamberlin, Hall and White, and C. E. Perkins, Esq., appearing for the complainants.

S. E. Baldwin, Esq., appearing for the defendants.

26 *Deposition of Frank L. Pope.*

FRANK L. POPE, a witness produced by the complainant, being duly cautioned and sworn, in answer to interrogatories, as written below, testified in his answers, as follows, viz:

Int. 1. What is your name, age, residence, and occupation?

Ans. 1. Frank L. Pope; age, thirty-five; residence, New Jersey; occupation, electrical engineer; am one of the petitioners in this case. In addition to myself there is James N. Ashley, of Greenville, New Jersey; James D. Lincoln, resident in the same place; Stephen C. Hendrickson, of Brooklyn, New York. We do business as a co-partnership under the name of Electric Railroad Signal Company, at 21 Cortlandt street, in New York. Letters patent of the United

States were issued to me, dated July 1, 1873, No. 140,536; a copy of which is hereto annexed, marked Exhibit A. I am not still the owner of this patent. I have assigned it to said copartnership. This paper is the assignment (copy annexed and marked Exhibit B). I was connected with the telegraphic business, as operator, from 1857 to 1864; at that time was appointed and served two years as assistant engineer on the Russo-American Telegraph Company's line. I was afterwards two years superintendent of the Gold and Stock Reporting Telegraph Company. Have since been engaged as electrical engineer in various kinds of work. Have often been called upon to give testimony in patent cases as an expert, in which the practical application of electricity to mechanism has been involved. The invention described in the patent put in consists in a combination of electric circuits for the purpose of operating a series of signals placed at intervals along the line of a railway, by which means a number of signals may be operated by a single battery. A positive and negative conductor extends along the entire line of the railway and parallel to it; these are attached to the respective poles of the same battery. Each signal is provided with two electro-magnets, one of which serves to exhibit the signal and the other to conceal it.

27 A series of circuit closers, so arranged as to be operated in succession by a moving train, when passed over by the train close the electric circuit between the positive and negative conductors, in such manner as to include and operate the magnet which displays the corresponding signal. When the train, in its progress, reaches the next succeeding signal, that signal is displayed by the same means, while from the same circuit-closer a branch current proceeds by a separate conductor back to the second magnet of the signal last passed and reverses the position of said signal. Thus, as a train passes along a railway, it operates to exhibit the signals successively, each signal in turn being reversed at or near the same time that the one in advance is exhibited. The novelty of the invention consists in the combination and arrangement of the parts, by means of which a series of two or more signals situated at some distance apart may be operated in succession from the same battery, thus avoiding the necessity of maintaining a separate battery for each signal. I have examined the system of signals now in operation on the Eastern railroad in Massachusetts, and referred to in the stipulation in this case. The series of signals which I have examined were in the vicinity of Chelsea, on that railroad.

I have made a diagram which exhibits the apparatus which I examined, or so much of it as is material to this case, which I annex, and is marked Exhibit C.

A battery of perhaps one hundred cells is placed in the station building at Chelsea. One pole of this battery—I think the negative pole—is connected to the earth.

A conductor is attached to the other or positive pole of the battery, consisting of an insulated wire extending along parallel with the track upon poles. This wire which I examined extended toward Boston, the end remote from Chelsea being disconnected, or, as it is termed, open. A second conductor, consisting of another similar

wire insulated and attached to the same poles, was arranged parallel to the first one. The second wire was open at Chelsea, and connected with the earth at its remote end.

The first mentioned wire I have shown in the diagram, and marked "positive conductor;" the second wire is marked "negative conductor." At a short distance from the station a semaphoric signal is placed, consisting of a red disk balanced upon a lever. This was placed in the cupola of a small building at the side of the track. An electro-magnet was arranged with its armature attached to said lever, so that when brought into action the red disk on the other end of the lever would be moved into a position to render it visible through an opening in the cupola. A latch or detent was placed in a position to fasten the lever after the action of the magnet had ceased, and thus continue the exhibition of the signal. A circuit-closer was placed upon the track at a point near the signal, which consisted of a lever so placed as to be depressed by the wheels of a passing train, which movement caused the circuit to be closed by pressing two springs together. When the circuit was thus closed by a passing train a connection was formed between the positive and negative conductors, and the electric current, in passing from one to the othes, passed through and operated the magnet by which the signal was displayed. At a point perhaps a mile distant another signal was arranged in precisely the same manner in connection with the [a?] second circuit-closer, and the same positive and negative conductors. An additional circuit-closer, placed upon the track in the vicinity of this last-named signal, was arranged to form a connection from the positive to the negative conductor by the way of a third wire running upon the poles back of [to?] the signal first mentioned, where it passed through and operated a second magnet, which lifted the latch or detent, and allowed the disk to return to a position concealing it from view. I examined two of these signals, and saw many others along the line of the road.

28

I find in this arrangement thus described the combination claimed in the first claim of said patent, consisting of a battery in combination with positive and negative conductors, two or more electro-magnets for operating visual signals and two or more circuit-closers placed at intervals along the line of the railroad. Also the combination claimed in the second claim of the patent, consisting of a battery in combination with positive and negative conductors, two or more electro-magnets for reversing visual signals, and two or more circuit-closers placed at intervals along the line of the railway. I also find the combination claimed in the third claim of a battery, positive and negative conductors, [a?] circuit-closer and electro-magnet for actuating a signal, with a second circuit-closer, wires, and a magnet for reversing said signal.

29

Cross-examined by Mr. BALDWIN:

I consider myself familiar with the inventions in electrical apparatus made [during?] the last ten years and patents that have been granted in this country for such apparatus. For perhaps, eight or ten years, I have been thus familiar. I knew in 1867 of Mr. Hall's

first patent for switch-alarms No. 62414. I have been, during the same time, quite familiar with foreign inventions of electrical apparatus. The first case in which I was called to testify as an expert in electrical apparatus, was a case between Mr. Laws and Mr. Calahan. It was an interference case of printing telegraphs. Was in 1868. The last case was Gamewell & Co. *vs.* McCullough, last week; was before a commissioner in a case pending in a circuit court for the southern district of New York, I believe. I am the author of communication in the American Artisan, of March 27, 1872, page 203, which is put in and marked Exhibit 1; also the article in the subsequent number of same paper of April 3, 1872, on page 218.

Prior to my patent, a mode of operating a series of visible signals by electricity along a railroad track had been known and practised. The mode of doing this was by the use of positive and negative conductors which were the prolongation of the positive and negative poles of one or more batteries. There was no novelty in the use of an electro-magnet with an armature connecting with a signal, nor of closing the circuit by the wheels of a moving train of cars passing over the rails, nor no novelty in so arranging the apparatus that simultaneous[ly] with the display of one signal another should be reversed or concealed, nor no novelty in insulating successive sections of the track so that a train of cars in passing along would operate to close a new circuit, as it passed over each section.

Re-examined by Mr. PERKINS:

I find on examining the assignment of the patent referred
30 to in my direct evidence that the number stated therein is incorrect, the date and title is correct. When it was executed I had several patents, and some other of them may have had that title, but no other that date, either of the same or different title.

I think I have had a patent of that number, and that it is some invention connected with signals, probably. Nor do I know for a certainty that I had it at the date of this assignment.

Int. 2. State what was the object of making and delivering the paper marked "B."

(Objected to, as seeking to vary a written instrument by parole, and also as irrelevant.)

The object of it was to transfer the patent, marked "Exhibit A," to the copartnership, the complainants.

FRANK L. POPE.

Subscribed and sworn to before me, this 9th day of November, A. D. 1876.

EDWIN E. MARVIN,
U. S. Com'r and Special Ex'r.

It is stipulated that the original of Exhibit B shall be produced for examination and exhibition in court upon trial.

Deposition of Moses G. Farmer.

M. G. FARMER, sworn for the complainants:

My name is Moses G. Farmer; my age is fifty-six; legal residence, Salem, Mass.; at present stationed at naval torpedo station, Newport, R. I.; am [an] electrical engineer; I was a telegraph operator for some time in 1847 to 1850; was superintendent of Vermont and Boston Telegraph from 1850 to 1851; was associated with Dr. Wm. F. Channing in the invention of the American fire alarm telegraph, and superintendent of its construction in Boston, and afterwards of its operation, a period extending from July, 1851, to July, 1855. Since then I have been employed in a great variety of electrical experiments and
31 researches; during the last four years much of my time has been occupied at the Government station at Newport. I have endeavored to keep tolerably acquainted with the progress of electrical science, and its application to industrial uses. I have been frequently called to testify in cases of interference, and occasionally in the United States courts in relation to matters of electricity and other matters. I have examined the patent, "Exhibit A," and think I understand the scope of the invention. The invention appears to be a combination of well-known devices for the purpose of indicating, to the driver of a locomotive especially, the condition of the track immediately in front of him, and for indicating to a following locomotive the fact that the track is free for him to enter upon or not. Among these devices I find a galvanic battery represented at B in the figure. The poles or terminals of this battery are prolonged by conductors that are marked in same C and Z. These conductors are arranged as ordinary telegraph wires along the side of the railroad. This electric circuit is an open circuit in its normal condition of rest. There are numerous points along the road where this circuit can be closed by the passing of a locomotive along the road. Near these points of closure are located an electro-magnet, M, for showing the signal, and another, *m*, for concealing the same. There is also some suitable device for closing the circuit at this spot through the action or agency of a passing locomotive.

In the diagram, looking at wire 6, wire 6 is connected with conductor C, attached to the positive pole of the battery, also to one terminal of the displaying magnet M^1. The other terminal of this magnet is connected to the circuit-closer, which is operated by the passing locomotive, so that when the locomotive passes this point, the circuit of the battery is closed, and includes in it the battery B and a portion of the wires C and Z, the two wires 4 and 6, the electro-magnet M^1, and the circuit-closer a^1. This circuit-closer a^1 simultaneously closes another branch circuit which includes the battery B, the wires 5, 7, and 8, the concealing magnet *m*, and the circuit-closer a^1, the object being to display the signal M^1 which the train is approaching, moving in the direction of the arrow, and to conceal the signal
32 last passed by, by means of the electro-magnet *m* at the station last passed over. The device here shown simultaneously displays a signal, M^1, and conceals the signal at the station imme-

diately in the rear. The circuit-closer, a^1, performs both these functions simultaneously. Although this device performs these functions simultaneously, I do not consider this an essential feature of the invention, as two circuit-closers might be used at this point, one for operating the display magnet M^1, and the other for operating the concealing magnet m at the rear station. At a^2, m^2, and M^2 I find a similar set of devices connected to the conductors C and Z. This arrangement of devices seems to have been so contrived that a single battery, B, connected to the conductors C and Z, and located at any convenient position along the line of the road, should serve to operate any desirable number of signals situated anywhere along the line of the road; thus rendering it more convenient and less expensive to maintain in readiness for action an amount of battery power sufficient to operate all the signals along the line of the road, without the necessity of having the batteries distributed at many stations. It is thus more convenient to keep the battery warm and in good working order; and, since the battery is used but little of the time, it being well known that the waste of the battery is largely due to the local action, it is manifestly more economical to maintain one single battery than to maintain many batteries of the same size scattered at different stations along the road, as was some time the practice. There is no difference in the accuracy, only that it is the easier to be sure that one is right than that many are right.

I have examined to some slight extent the system of railway signals now in use on the Eastern railroad, in Massachusetts. I walked over the tracks from Everett to Chelsea and observed the arrangement of wires. Saw the signals operated by passing trains. I rode from Chelsea to Salem, and saw the signals operated as the train approached them. Saw some of them disappear after another train had some time passed. Examined the arrangement of battery and conductors at Salem. Examined the internal construction of
33 one set of signal apparatus. Examined one of the circuit-closers, and, from what I saw of its workings, think that I understand in general its construction and mode of operation.

Exhibit C represents correctly in general the system of signals as I saw it at Salem. I think it is essentially the invention described in the patent in this suit—Exhibit A. The battery B in Exhibit C corresponds to the battery in the patent. The conductor C corresponds to the conductor C in the patent. The conductor Z, composed partly of line wire and partly of earth, corresponds to the conductor Z in the patent.

The circuit-closer a and the display magnet m correspond to the circuit-closer in a and the display magnet m in the patent.

The releasing or concealing magnet m corresponds to the concealing magnet m in the patent.

The circuit-closer b in the Exhibit C corresponds to the circuit-closer a^1 in the patent. The circuit-closer b in Exhibit C serves to call into action the releasing magnet m at the station last passed over, even as the circuit-closer a^1 in the patent serves to call into action the releasing magnet m at the station last passed over.

The short wire 7 in Exhibit C leads to the releasing magnet *m* at the preceding station, substantially as does the wire 7 in the patent.

In Exhibit C are the two main conductors C and Z, which serve to connect the battery B, even as do the main conductors C and Z in the patent.

The short subsidiary wire 7 in Exhibit C performs the same function as does the same wire in the patent. The fact that a portion of the conductor Z in Exhibit C is made up of earth instead of being all wire, as in the patent, while it is a good method of equalizing the resistance of the circuit, does not essentially alter the nature of the invention, since the patent states that the respective resistances of the several circuits should be so adjusted that they will be as nearly as possible equal to each other.

There are many well-known methods of adjusting these resistances, such as varying the dimensions of the wire on the mag-
34 nets *m* and M; likewise the resistances of the branch wires 3 and 6, 8 and 13, 7 and 12, &c., may be so varied as to secure this equality of resistance.

The construction of the magnet M, and of the conductors C and Z, can be so varied as to require more or less battery at B. An essential feature of the invention seems to be this: only one battery need be used, having two principal conductors along the line of the road, with many permanently fixed branches, and many stations or places at which signals can be displayed by the action of this one battery, the circuit of which is normally open, except when momentarily called into action by a passing train. I find this invention as thus detailed in diagram Exhibit C.

I do not consider the material of which conductors C and Z are composed, one being of wire and one of wire and earth, as a material part of the invention. The earth as one of the materials for a conductor of a battery has been long in use, having been used as early as 1837, to my knowledge. I should prefer to have the circuit entirely metallic, as the insulation could be better maintained.

In the construction of the fire-alarm telegraph, we prefer to use a circuit wholly metallic, because then a single earth contact would do no harm; it would require at least two. If in the diagram, Exhibit C, a sufficiently good contact were made between the earth and conductor C and G that (?) a sufficiently strong branch current, when the circuit is closed at *b*, would not pass through the releasing magnet M, to conceal the signal at this station, and thus the danger signal would still be shown to a following train.

It would require an earth contact with each of the conductors C and Z, in the patent, at the point G, to produce this effect.

Cross-interrogatory by Mr. BALDWIN:

I do not recognize any single device of this patent Exhibit A as new. The only novelty is in its combination and arrangement. There is no novelty in arranging a single battery to operate by the increase (?) of many conductors, many different signals at many different points. I consider that the novelty lies in arranging

35 them along the side of a railroad so that each shall be operated by the passing locomotive, in the proper order of succession.

Cross-int. 1. Was there, at the date of Pope's patent, any novelty in creating a number of subsidiary electric circuits, by connecting subsidiary wires with two main wires proceeding from one battery, as the prolongations of its positive and negative poles?

Ans. There was not; but I consider the novelty of the invention in so arranging these circuit-closers and signals that they should be operated automatically by the passing trains in definite and predetermined succession.

Cross-int. 2. In regard to the fire alarm telegraph, is the circuit there normally closed or open?

Ans. Normally closed.

Cross-int. 3. And does not that make a difference between its operation and that of the system of railway signals observed by you on the Eastern railroad, as respects the expediency or effect of earth connections or contacts?

Ans. I think not.

Cross-int. 4. The circuit there on the Eastern railroad was an open one, was it not?

Ans. Yes, normally.

Cross-int. 5. Would it not be extremely difficult to equalize the resistances of the several circuits extending for any considerable length along a railroad line, if you relied only on the device of varying the sizes of the metallic conductor?

Ans. It would present no practical difficulty at all to a competent electrician, and the limits between which the resistances might vary might be very great and still the system work successfully.

Cross-int. 6. Is it not true that the narrower the limits of these variations the more perfect the device?

Ans. Hardly. I can conceive of a device working equally well, if proper attention be paid to its construction, if the resistance be twice as great in one case as in another, and even more.

Cross-int. 7. Do you mean to be understood that an equalization of these resistances is not an end to be aimed at?

36 Ans. Not necessarily; both the displaying magnet and the concealing magnet, in order to operate satisfactorily, must have at least a minimum of lifting power, and if some have twice or three times that power it will do no harm, for magnets can be so constructed as to have the same resistance each, and yet one have twice the lifting power as the other; the necessary lifting power in the magnet is the thing to be aimed at rather than the equalization of resistance.

Cross-int. 8. Do you consider the equalization of the resistances of any importance in railroad signal apparatus?

Ans. Only in so far as it might make the magnets of nearly similar construction. The attainment of adequate lifting power is of much more importance.

Cross-int. 9. Have you ever seen in practice a long line of electric railroad signals, of the kind in question here, successfully operated

for any length of time without making the earth serve as part of one of the main conductors?

Ans. I have examined no great length of railroad signals. I have seen the working of the signals on the Eastern railroad both recently and a few years since, and I have seen the working of the system on the Old Colony road; also on the Boston and Albany road; all these, as I understand, use the earth as part of the circuit. I have examined no other system sufficiently to state whether it uses an earth circuit or not. I have no objection to saying, in response to the main question, that I have not.

Cross-int. 10. Is the use of the earth circuit one appropriate method of equalizing these resistances?

Ans. As used by the Eastern railroad it is.

Cross-int. 11. Does Mr. Pope point out in his patent any mode for equalizing the resistances, that you recollect?

Ans. I do not recollect that he does.

Cross-int. 12. Do you know whether before Mr. Pope's patent any device was known or patented for actuating several signals, at intervals along the line of the railroad, by the use of electro-magnets operated by a single battery?

(Objected to, as not relating in any way to any part of the direct examination of the witness, but being a part of the defendants' case.)

37 Ans. I am not familiar with any.

Cross-int. 13. Do you know anything of the existence of such a device?

(Objected to on same grounds as above.)

Ans. I have heard that there were devices, but I do not know the date of them; whether they preceded or succeeded Mr. Pope's patent.

Cross-int. 14. Have not your studies and researches been less in the direction of railroad signal apparatus than concerning fire-alarms, torpedoes, and other branches of electrical science?

Ans. I think they have—I might add, especially of late years.

Cross-int. 15. Have you ever read Thomas S. Hall's patent for improvement in electro-magnetic signals of Dec. 7, 1869?

Ans. I do not know that I ever have.

Cross-int. 16. Have you read any of Mr. Hall's specifications or patents?

Ans. I have read one; No. 165,570, Hall & Snow, dated July 13, 1875.

Re-examined:

Int. State whether, if in Exhibit C a wire was substituted, the resistance of the circuits would be equalized in the same manner as they are equalized in apparatus described in Exhibit C.

Ans. They would be equalized in substantially the same manner.

Int. Is, in fact, the equalization due to the use of the earth as a partial conductor, or to the wires, in Exhibit C?

Ans. It is due to the arrangement of the wires wholly, and not at all to the fact that the earth is used as a portion of the conductor.

By Mr. BALDWIN:

38 Recross-int. Do I understand you that you deem the use of the partial earth circuit on the Eastern railroad as having no effect towards equalizing the respective resistances of the several circuits?

Ans. No different effect from that which a metallic conductor would have, of the same resistance that the earth presents.

Recross-int. 2. Would it be as easy to adjust and maintain such a metallic conductor so as to effect such equalization, as it would be to rely on the resistance of the earth?

Ans. It would be more expensive to rely on the resistance of the earth. It is well known that the resistance of the earth varies, oftentimes more than the resistance of a metallic conductor would; still I would not recommend the substitution of a metallic conductor in place of the earth in precisely such an arrangement of circuits as I find in use on the Eastern railroad.

MOSES G. FARMER.

Subscribed and sworn to before me, this 9th day of Nov., A. D. 1876.

E. E. MARVIN,
U. S. Commissioner and Special Examiner.

United States Circuit Court, District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL COMPANY.
vs.
THE HALL RAILWAY SIGNAL COMPANY.

Proofs for final hearing on the part of the complainants in rebuttal taken before E. E. Marvin, special examiner, under and pursuant to the sixty-seventh rule in equity, as amended, at New York, January 17, 1879.

39 Present: Mr. Chamberlin, for complainants, and Mr. Van Santvoord, for defendants.

Deposition of James N. Ashley.

JAMES N. ASHLEY, witness produced on the part of the complainants, being duly sworn, in answer to questions proposed by Mr. Chamberlin, says as follows:

Int. 1. Please state your name, age, residence, and occupation?

Ans. My name is James N. Ashley; my age is fifty-one years; my residence is Jersey City; and my regular occupation is editor of the Journal of the Telegraph, and I am the Ashley named as one of the complainants in this case.

Int. 2. Are you familiar in any way, and how, with the general business of telegraphing and of railroad electric signals?

Ans. I have been familiar with telegraphing since 1851 as an op-

erator, superintendent of telegraph lines, and since 1868 as an editor of telegraphic journals. I am familiar with electric railway signal business.

Int. 3. Are you familiar with the book published in 1869 by Frank L. Pope, entitled "Modern Practice of the Electric Telegraph"?

Ans. I am.

Int. 4. Were you in any manner connected with Mr. Pope in the preparation of that book for publication?

(Defendants' counsel object to the question, as irrelevant.)

Ans. I was a partner of Mr. Pope in publishing the book. Mr. Pope prepared the book. I attended to the business part.

Int. 5. When did your association with Mr. Pope for that purpose commence?

Ans. In 1868.

Int. 6. Please examine the book I now hand you, and which contains complainants' Exhibit R, and say whether it was one of the edition of Pope's book which was published in 1869?

Ans. It is.

Int. 7. How do you know?

40 Ans. It is one of a hundred copies of the first edition, which was especially bound in a better style than the rest of the edition, to be used for presentation copies; a few of this number were sold at a half a dollar more than the rest of the edition.

Int. 8. State whether or not you have been continuously engaged in business from that time to and including this date with Mr. Pope.

Ans. I have.

Int. 9. What was your next business enterprise?

Ans. Our next business enterprise was, that we established a telegraph concern, which was not a corporation, called the Financial and Commercial Telegraph.

Int. 10. When was that?

Ans. In 1869.

Int. 11. Where were you when you first commenced to carry on the business of that concern?

Ans. In Matthews' building, Nos. 5 and 7 New street.

Int. 12. Can you tell at what season of the year that you moved into that office?

Ans. It was in the fall of 1869.

Int. 13. How long were you confined to that business alone, or what was the next business you added to it?

Ans. We were confined to that business alone only a few months, when we combined with it the construction and sale of private telegraph lines, for the operation of which Mr. Pope and Mr. Thomas A. Edison had invented a printing telegraph especially adapted to that service.

Int. 14. Was the business with this addition carried on in the same office, or did you remove; and, if so, where?

Ans. On the first of April, 1870, I think, or about that date, we

removed to a front office on Broadway, on the same floor of the same building.

Int. 15. How long did you carry on that business, and to whom did you sell out?

Ans. We carried on that business until May, 1870; we sold the business that covered the transmission of quotations of gold, and organized a corporation, called the American Printing Tele-
41 graph Company, to which was sold the private line telegraph business; the business of the latter company being conducted by Mr. Pope and myself under the direction of a board of directors.

Int. 16. State whether the last-named branch of your business was disposed of at the same time as that which covered the transmission of quotations of gold, or at a later period.

Ans. It was really one transaction; that is, Mr. Pope and myself received stocks for our interest in the private line business in the new company, which stock was subsequently sold to General Marshall Lefferts, and we went out of the business in the spring of 1871.

Int. 17. Do you remember when you first saw Hendrickson's signal machine; I mean any signal machine of Hendrickson's, or exhibited by him?

(Objected to by defendants' counsel, as irrelevant and immaterial.)

Ans. It was in the early spring of 1871; I cannot fix the date exactly.

Int. 18. Where did you first see it, and if at the suggestion of any one, state by whom?

(Same objection.)

Ans. I saw it at an office in New street—I cannot recollect the number—where it was set up for exhibition; Mr. W. O. Lewis, a mutual friend of ours and of Mr. Hendrickson, informed us that Mr. Hendrickson had invented an improved railway signal, and suggested that Mr. Pope and myself should call and see it, which we subsequently did.

Int. 19. Did any one accompany you at that time; and, if so, who?

Ans. Mr. Pope, as stated in my previous answer.

Int. 20. Did you see Mr. Hendrickson?

Ans. We did.

Int. 21. At this time, state whether or not you and Mr. Pope occupied the same room as well as the same office.

42 Ans. We did occupy the same room.

Int. 22. Had Mr. Hendrickson, prior to this time, to your knowledge, ever been to your office to see you or Mr. Pope upon any business?

Ans. Not to my knowledge.

Int. 23. How much of the time were you in the office, and was you or Mr. Pope the special office man?

Ans. I was in the office usually during business hours, and was recognized as the one who especially conducted the business of the concern and as the business man.

Int. 24. From your relation to the office and its business, would you or not have been likely to know if Mr. Hendrickson had been there to see either you or Mr. Pope for any business purpose?

Ans. I should, as negotiations and all strictly business matters were referred to and conducted by me.

Int. 25. State whether or not any business arrangement between you, Pope, and Hendrickson subsequently resulted from this interview.

Ans. After we had seen Mr. Hendrickson's signal, Mr. Hendrickson called at our office from time to time, and we conversed with him in regard to railroad signals and the railroad signal business; we were about to dispose of our interest in the American Printing Telegraph Company, and expected to surrender that business; Mr. Pope and myself, in view of this, had consultations in regard to what we should take up next; I suggested that in my opinion Mr. Hendrickson had a good thing, and that as he was looking for somebody to take hold of it and carry it through and establish the business it might be well for us to make an arrangement with him for that purpose; after some consideration Mr. Pope agreed with me, and I spoke to Hendrickson in regard to it, and told him that as soon as we had disposed of our interest in the American Printing Telegraph Company we should have some money, and if we could agree upon the terms with him we would take hold of it after we had sold out our interest in the American Printing Telegraph Company; we made a contract with Hendrickson, and have been interested with him in the electric railway signal business from that time until now.

43 Int. 26. When was the arrangement made?

Ans. That was made in the latter part of the spring of 1871, I think.

Int. 27. In the arrangement so made, state whether your department continued as before, and what special branch or branches of the business was to employ Pope and Hendrickson?

Ans. It did. Pope and Hendrickson attended to the scientific and practical part of the business, that is to say, they made new inventions to perfect the system, and attended to its practical introduction upon railroad lines.

Int. 28. Had you or have you now practical knowledge of the details of machinery or inventions, or only a general theoretical knowledge upon this general subject of railroad signals and their mode of operations?

Ans. Those matters were referred to Pope or Hendrickson as business matters were referred to me, and I gave them no special attention or had any special knowledge of them. In a general way I was informed of the results which it was desired to accomplish, and when these were effected, but of the details, scientific and mechanical matters, I only had this general theoretical knowledge.

Int. 29. State whether all inventions made by Pope and Hendrickson, or either of them, were by your contract to be the property of the company, or only such as having been sufficiently perfected

to be brought to your attention should, upon consultation, be adopted and patented by or for the company.

Ans. Only such as were adopted and patented by the company; but the company had the right to adopt any invention which applied to electric railway signalling made by either of the partners.

Int. 30. Where was your next office, and when did you move to it?

Ans. Our next office was 194 Fulton street, and we moved to it on the first of May, 1872.

Int. 31. How long did you occupy that office?

Ans. One year.

Int. 42. Where was your next office, and when did you move into it, and how long did you occupy it?

44 Ans. 38 Vesey street; we moved into it May 1st, 1873, and we occupied it until, I think, about the fall of 1876; I do not recollect exactly when we moved from there; it was some time that fall.

Cross-examined by Mr. VAN SANTVOORD:

Cross-int. 33. Are you in the employment of the Western Union Telegraph Co.?

Ans. I am.

Cross-int. 34. How long have you been in their employment?

Ans. Since February 1, 1877.

Cross-int. 35. What are the names of the telegraphic journals of which you have been editor since 1868?

Ans. From February, 1868, to February, 1877, The Telegrapher, and from February, 1877, to this date, the Journal of the Telegraph.

Cross-int. 36. Who was the editor of the Journal of the Telegraph in 1870?

Ans. James D. Reid.

Cross-int. 37. What was the name of your firm or association to which you refer in your answer to int. 26, which was made in the spring of 1871 between Mr. Pope, yourself, and Mr. Hendrickson?

Ans. The Electric Railroad Signal Company.

Cross-int. 38. Were you a firm or a corporation?

Ans. We were a firm.

Cross-int. 39. Did you at that time know of the existence of Mr. Hall's incorporated company, entitled the Electric Railway Signal Company?

Ans. I did know that Mr. Hall had a company, but I don't recollect about the name; I have no doubt I knew of the existence of the company and its name, but gave it no especial attention.

Cross-int. 36. Did your firm, the Electric Railroad Signal Company, previous to the commencement of this suit, I mean your firm and its successors doing business under that same name, put

45 up for practical operation on any railroad line any electric signal apparatus; and, if so, state when and on what road?

Ans. Well, in the fall of 1871 we put signals on the Boston & Lowell road; in 1872 we put signals on the Philadelphia & Erie

road, between Northumberland, and I do not recollect the other station, and in the same year on the Pennsylvania road, at or near Pittsburgh, and afterwards on the same road at Greensburgh; also on the Lehigh Valley road near Mauch Chunk, the Chicago & Northwestern road, and the Illinois Central road near Chicago; that is all that I recollect; there might have been one or two experimental signals besides that I do not recall; am not certain as to the dates in all these cases, and think that the last two named were put on subsequent to the commencement of this suit.

Cross-int. 37. Are such signals now in use on said roads?

Ans. I believe some of them are, but cannot state positively of my own knowledge.

Cross-int. 38. Is it in use on the Boston & Lowell now?

Ans. Not to my knowledge.

Cross-int. 39. How long did it continue in use on that road?

Ans. I cannot tell; some months.

Cross-int. 40. Why did the road cease using it, if you know?

Ans. I cannot tell.

Cross-int. 41. Did that road pay you anything for your signal apparatus?

Ans. It did not. The signals were put up mainly to experiment with, and not under contract.

Cros-int. 42. Did you put up the signals on the other roads you have mentioned in the same way as upon the Boston & Lowell without contract from them to pay you?

Ans. Sometimes we did, and sometimes it was understood that they should pay us as if the signals were continued.

Cross-int. 43. Have any of said roads that you have named paid your firm anything for the use of your signal apparatus?

Ans. They have.

46 Cross-int. 14. Which roads of those named have so paid?

Ans. The Philadelphia & Erie, the Pennsylvania, the Illinois Central, the Chicago and Northwestern, the Milwaukee & St. Paul. That is all that have paid, as I recollect.

Cross-int. 15. Did those roads pay merely for putting up the signals or a royalty?

Ans. The price of the signals included the royalty.

Cross-int. 16. Was the royalty so much per mile, or how otherwise?

(Objected to by complainants' counsel, as irrelevant.)

Ans. It was not calculated at so much a mile. As the price of the signal included the royalty, it could not be calculated at so much a mile.

Cross-int. 17. How otherwise was the royalty charged?

Ans. It was added to the price of the signals.

Cross-int. 18. Did your firm charge a royalty which was calculated on the number of signals used?

Ans. It depended on circumstances. We took into consideration the advantage expected to be derived from its introduction upon cer-

tain roads or in certain sections of the country, and made prices accordingly.

Cross-int. 19. Then you did not charge a fixed sum as a royalty, but made a charge to each road which was charged at all, according to an especial bargain with the road?

Ans. That was the fact.

Cross-int. 20. Is it not also a fact that in the case of each of those railroads you have named your application thereon of your signals was a trial or test application to induce the road to adopt your signals?

Ans. The expectation that we should obtain further orders was an element in the arrangements made with such roads, but was not a condition of such arrangement.

Cross-int. 21. Did the amount that your firm received from any of the roads you have named cover the cost of your firm of putting up and applying the signals on such roads respectively?

47 (Complainants' counsel object to the question as irrelevant and immaterial, and extend the objection to the whole subject-matter.)

Ans. I cannot answer the question definitely.

Cross-int. 22. Did you apply more than one signal on any of the roads you have mentioned?

Ans. We did.

Cross-int. 23. On which?

Ans. I don't think there was any road on which we did not apply more than one signal.

Cross-int. 24. What was the largest number of signals which you applied on any one road?

Ans. That I cannot say. The practical application and the putting up of these signals was done by Pope and Hendrickson, or under their supervision.

Cross-int. 25. You were asked in int. 29 about your contract with Messrs. Pope and Hendrickson; will you please produce that contract or a copy of it?

Ans. I have not got that contract or a copy of it with me, but will get it for you.

Redirect-int. 26. Did Hall advertise in your paper; and, if so, when, and under what name?

Ans. I think that Mr. Hall did at one time advertise in the paper, but the details of the advertisement I do not remember.

Redirect int. 27. Do you or not remember that Mr. Hall at one time advertised in your paper, giving his company the name, or substantially the name, of Hall Patent Railway Switch and Drawbridge Signal Company?

Ans. I don't recollect. I think that was the name, but am not confident. I can find the advertisement in the file of the paper, which I have, and will produce it, if wanted.

Redirect int. 28. In naming your company, do you remember whether you personally had anything to do with the discussion what it should be called?

Ans. I do; I recollect our discussing the subject of a name; that is, our three then partners.

48 Redirect int. 29. Was anything said by either of the parties, or had you in mind or thought at that time, or at any time prior to the adoption of the name, Hall's company, and its name as being similar to yours?

Ans. I do not think there was. I do not recollect anything of the sort. I do not recollect the details of the discussion.

Redirect int. 30. In your opinion, would you or not be likely to remember it if there had been a purpose expressed by others, or a thought or a desire on your part to adopt a name similar to Hall's?

Ans. I certainly should.

(The witness produces and exhibits to defendants' counsel the original contract called for in cross-int. 25.)

Recross-int. 31. Were you in the habit of reading the newspaper called the Railroad Gazette during the years 1869, '70, and '71?

Ans. I don't recollect. I think my exchange with that paper commenced later than that. I might have seen odd numbers, but think that I did not commence to receive it in exchange regularly until after that.

Recross-int. 32. Don't you recollect of seeing in that paper, before you formed your firm with Pope and Hendrickson, an advertisement of the Electric Railway Signal Company?

Ans. I do not.

J. N. ASHLEY,

Subscribed and sworn to before me, this 17th day of January, A. D. 1879.

E. E. MARVIN,
Examiner.

Deposition of Stephen C. Hendrickson.

STEPHEN C. HENDRICKSON, a witness produced on the part of the complainants, being duly sworn, in answer to questions proposed by Mr. CHAMBERLIN, says as follows:

Int. 1. Please state your name, age, residence, and occupation.

Ans. My name is Stephen C. Hendrickson; my age is
49 forty-seven; my residence is 74 De Voe street, Williamsburg, New York, and my occupation is constructor of telegraph lines.

Int. 2. How long have you been in that business?

Ans. I have been constructing lines since 1852. My first experience was as an operator, and continued from 1852 to 1859, with occasional employment in repairing and erecting lines. From that time, 1859, I was superintendent of the city lines in New York up to 1861, then again constructing lines and submarine cables, and superintendent of construction for different companies till 1868. After that I was employed occasionally during 1869 by the Hall Electric Railway Drawbridge and Switch Signal Company, the Flush-

ing & North Shore R. R. Company, and the Morris & Essex R. R. Company until the middle of December, 1869. After that I was unemployed until the middle of February of 1870, and from that time was engaged as superintendent of constructions by C. T. & J. N. Chester in erecting the New York Fire Alarm. That was completed in August of that year. I remained with them until the middle of October, and then went to Detroit for Gamewell & Co., fire-alarm contractors, and completed the fire alarm of that city about the 24th of November of that year. I returned to New York and was re-engaged temporarily by the Chesters in constructing lines and other electric wires until the middle of January, 1871. After that I was engaged on my own account in completing a railroad signal, which I completed in March, 1871, and which I afterwards patented and put on exhibition at 22 Broad street, in the office of W. O. Lewis. There the matter was introduced to Pope and Ashley by W. O. Lewis, and after a few months I formed a business connection with said Pope & Ashley, which has since continued, J. D. Lincoln becoming connected with us in business at a later date.

Int. 3. State whether or not the Hall Electric Railway Drawbridge and Switch Signal Company was the company then managed by Thomas S. Hall, now manager of the defendant company.

Ans. It was.

50 Int. 4. By what person were you then employed, and under what person did you then work for said company?

Ans. Thomas S. Hall.

Int. 5. Had you, prior to your employment by said company, invented anything in the signal or insulator line?

Ans. I had.

Int. 6. What?

Ans. An insulator for leading wires into buildings and cable houses, and other points where the wires should be protected to prevent the escape of electricity to the earth.

Int. 7. When did you first have any conversation with the complainant, Pope, in reference to signal business?

Ans. In the spring of 1871, May 3.

Int. 8. In making the last answer, do you refer to any memorandum made by you; and, if so, when was it made, and whether or not at the time of its date?

Ans. It was made in my diary of that year, at the date above mentioned, and was made on said date.

Int. 9. How long time were you employed by Thomas S. Hall for the company which you say he represented?

Ans. Irregularly, from about the middle of February to the 6th of December, 1869.

Int. 10. Did you apply to Mr. Hall for employment, or did he apply to you for your services?

Ans. He applied to me, through S. C. Bishop, now dead.

Int. 11. Prior to that time had you any acquaintance with him or his business?

Ans. I had not.

Int. 12. Why did you leave Mr. Hall's employment? State whether he discharged you, or failed to furnish you with further work.

Ans. He had nothing further to do. It was coming on cold weather.

Int. 13. Where did you live at the time you were employed by him?

Ans. 162 Ainsley street, Williamsburg, New York.

Int. 14. Where was your employment in his services?

Ans. On the Morris & Essex R. R., the New York & New Haven R. R., and Flushing & North Shore R. R.

51 Int. 15. Did he pay you when you ceased to work for him at the time you ceased to work for him?

Ans. He did not.

Int. 16. How much did he owe you at the time you ceased to work for him?

Ans. Between one and two hundred dollars. I cannot say precisely.

Int. 17. When did he pay it to you, or any part of it?

Ans. I received a check for $106\frac{25}{100}$ January 4th, 1870.

Int. 18. Had you corresponded with him in relation to it? Had you written to him or he to you about it?

Ans. I had written to him several times, and also went to meet him, but always found him absent.

Int. 19. Did you receive a letter or letters from him in relation to it?

Ans. I did.

Int. 20. What was the date of the first letter received from him after you left his service?

Ans. December 27, 1869.

Int. 21. Will you produce the letter?

Ans. I will. (Witness produced the letter called for, which is put in and marked Exhibit S.)

Int. 22. How was the check which you alluded to for $106\frac{25}{100}$ sent to you?

Ans. By mail.

Int. 23. Was or was it not accompanied by a letter?

Ans. It was—a letter dated Jan. 4th, 1870.

Int. 24. Will you produce the letter?

Ans. I will. (Witness produces the letter, which is laid in and marked Exhibit T.)

Int. 25. Please read the answer of the witness, Thomas S. Hall, fols. 422 to 425, inclusive, re-int. 84, defendants' evidence, and state whether anything of that kind, or in the nature of the thing there stated, ever occurred between you and Mr. Hall.

Ans. Nothing of that kind or nature ever occurred.

Int. 26. State whether or not Mr. Hall ever sent for you to meet him at the Stamford depot.

Ans. He did, several times, and at other points.

52 Int. 27. Did he ever, on any of these occasions, accuse you of taking his double circuit instrument and other devices to Mr. Pope's office, in Broadway, New York?

Ans. He never did.

Int. 28. Did you ever take said instrument and other devices, or any of them, to Mr. Pope's office, or to Mr. Pope for any other purpose?

Ans. No, sir; I never did.

Int. 27. Did he, while you were in his employment, or at or after the time you left his employment, ever address you in the language contained in said 424 and 425 folios of defendants' evidence? I alluded particularly to these words, in which Hall says he said to you that "I simply considered him an unmitigated scoundrel, and requested him to leave my employment and never again to apply to me for a day or an hour's work," or anything like that in word, meaning, or idea?

Ans. Nothing of the kind ever occurred.

Int. 28. You have already stated that he sent you, in a letter of January 4th, a check for $\$106\frac{25}{100}$. Was that all that he then owed you?

Ans. No, sir; it was not.

Int. 29. Has he ever paid you the balance that you then claimed?

Ans. No, sir.

(Counsel for complainants placed in evidence two letters furnished by Mr. Snow in compliance with complainants' request in cross-int. 85 of evidence of G. H. Snow, which are marked Exhibit U and Exhibit V, respectively.)

53 Adjourned to January 28, 1879, 10 a. m.

HARTFORD, *January* 28, 1879.

Met pursuant to adjournment.

Parties represented as heretofore.

At the request of Mr. Pope, communicated by telegraph, hearing adjourned to February 11, 1879, 10 a. m.

HARTFORD, *February* 11, 1879.

Met pursuant to adjournment.

Deposition of S. C. Hendrickson—Continued.

Parties represented as heretofore. Examination of STEPHEN C. HENDRICKSON resumed:

Int. 30. When did you, Mr. Hendrickson, form the business connection with Pope & Ashley, alluded to in answer to interrogatory 2?

Ans. The final arrangement was made June 14, 1871.

Int. 31. What was the business of that company?

Ans. It was the manufacture of railroad signals.

Int. 32. Were all the partners to be equally attentive to all parts of the business, or was it divided; and if divided, how?

Ans. Each one had his proper duty to perform. Mr. Ashley attended to the business and financial affairs, Mr. Pope to the scientific part, and I attended to the practical, putting up, and mechanical part.

Int. 33. How were the patents on inventions made by the partners, or either of them, taken out; that is, in whose name?

Ans. In the name of the inventor.

54 Int. 34. Had you made any inventions in this line when you made this arrangement with Pope & Ashley; and, if so, what?

Ans. I had made inventions. One covered by patent No. 115,610, and dated June 6, 1871, for an improvement on railroad signals. This was intended for switches, drawbridges, block signals, and station signals. I afterwards made other improvements, which were included in patent No. 129,408, dated July 16, 1872, issued to Hendrickson & Pope. There were some mechanical parts which Mr. Pope invented, which made it necessary for the patent to be taken out jointly. I will state the particular parts that were Mr. Pope's, viz: Relating to the endless screw on shaft and roller on end of lever; also the lamp attached to the signal. The balance of the invention was my own.

Int. 35. What was the gist of your invention described under this patent?

Ans. The track-lever combination, the switch combination, the double-circuit instrument, and the bell-ringing apparatus. This was all my inventions up to this time, except that mentioned in my answer to int. 6.

Int. 36. What was the first actual work done under this arrangement between you and Pope and Ashley of June 14, 1871?

Ans. On the Boston and Lowell railroad.

Int. 37. When was the work done?

Ans. In November, 1871.

Int. 38. At and between what places on that road?

Ans. At and between Boston and East Cambridge.

Int. 39. What was the work so done; show it by diagrams, if necessary?

Ans. It was intended to show when a train left Boston, and also the arrival at East Cambridge, displaying a danger signal at Boston until the train arrived at East Cambridge, or left. I can put in a diagram showing how the arrangement worked. Witness places in evidence diagram referred to which is marked Exhibit W.

Int. 40. Please explain the diagram briefly.

Ans. As the train was about to leave Boston station the
55 ticket agent depressed key K, which magnetized magnet M, also magnet G to bell, thus displaying danger signal D at right angles to its original position, in which original position it is nw shown in the diagram, and being held to its danger position by the aid of detent of magnet *m* without the aid of the large magnet M. As the train reached East Cambridge, magnet R was magnetized, by the aid of battery *b*, by the wheels of locomotive, which closed the circuit on the insulated rail T, that closing circuit W by means of battery B^1 and relay R, thus closing magnet *m* and releasing detent to shaft S and allowing signal to return to its original or normal position by the aid of a spring. The diagram that I have explained is Fig. 1.

Int. 41. Now, will you please explain the reverse of that which you have given us, making the train put on the signal and the ticket-agent take it off, as shown by Fig. 2 on same diagram?

Ans. The train arriving at East Cambridge in the opposite direction, closing relay R as in Fig. 1, closing magnet *m* through circuit W by the aid of battery B^1, and also closing circuit through magnet M and bell G, by the aid of battery B. After a train leaves insulated section T, both magnet M and magnet *m* are demagnetized, allowing lever to magnet *m* to be released from shaft S (referring to Fig. 1,) caught by hook attached to lever of magnet *m* to detent on shaft S, holding signal to a danger position until the arrival of the train at Boston. The signal then being returned, to its original or normal position mechanically, referring to Fig. 2.

Int. 42. Was this work done as permanent work under a contract with that company, or as experimental work by permission of the company, under the inspection of a commission of railroad men?

Ans. It was done, as I understood, as an experiment, and, if satisfactory, the arrangement would be to go into it still further.

Int. 43. How long did this work remain there, if you know?

Ans. From five to eight months.

56 Int. 44. Why was it moved?

Ans. Owing to the rebuilding of the new depot.

Int. 45. When was this completed and put in operation?

Ans. About the 9th of November, 1871.

Int. 46. How long did it continue in operation?

Ans. From five to eight months, as I have stated.

Int. 47. During that time, state whether or not it failed to operate at any time on account of the effect of wet weather upon that portion of the track that was insulated.

Ans. It did not.

Int. 48. Did it for any cause?

Ans. It did.

Int. 49. What was the trouble?

Ans. It was because of the wires getting crossed (the signal wire from Boston to East Cambridge) with the Western Union wires, owing to the Western Union's lines being reconstructed.

Int. 50. What did you do next after the Boston and Lowell work—I mean your firm when I say you?

Ans. It was putting up the signal at Bethlehem. I am mistaken; the next work was on the Pennsylvania railroad. It was at Millvale and East Liberty. I went with Mr. Pope to those points the latter part of July, 1872, and assisted him in erecting signals. I returned to New York August 8, leaving Mr. Pope there at East Liberty, where he remained to complete the work.

Int. 51. Please state what you personally did between the time that you left the Boston and Lowell work and the work that you described in your last answer.

Ans. My principal time was taken up in the construction of a line of telegraph for the Central railroad of Long Island from Flushing to Farmingdale.

Int. 52. When was that work done?

Ans. I commenced August 19, 1872, in constructing [it?] and finished October 10, 1872.

Int. 53. What was the next business you did?

Ans. Next I put up a signal at Bethlehem, Penn., and before finishing Mr. Pope telegraphed me to meet him at Sunbury,
57 Penn. This was October 28, 1872, that I received the telegraph from him. I started immediately, and met him at Sunbury the following morning. There I assisted him in putting up signals at Sunbury and Northumberland, Penn., on the Philadelphia and Erie railroad. After completing we returned, both Pope and myself, to Bethlehem, Penn., where we finished and put in operation the signal at Bethlehem, returning to New York in the evening of that day, November 6, 1872, Mr. Pope leaving me at Elizabeth, his stopping place, and I went on to New York.

Int. 54. When and where did you first hear Mr. Pope speak of a plan for operating a series of electric block signals by means of a single battery and battery wires or conductors extended along the line of a railroad substantially in the manner described in his patent, No. 140,536, Complainants' Ex. A?

Ans. During the time I was at Sunbury and Bethlehem.

Int. 55. Have you stated when you left Sunbury?

Ans. I believe I have. About the 6th of November, 1872.

Int. 56. Did he describe it to you at that time fully, or only partially, and did you make any diagram or memorandum of it?

Ans. He described it fully, and in such a manner that I made a diagram of it and showed it to him to know whether it was as he intended it.

Int. 57. State whether or not this was done while you was at Sunbury or Bethlehem.

Ans. It was done while we were at Bethlehem, or on the train going from Sunbury to Bethlehem.

Int. 58. Have you that diagram now?

Ans. I have. Here it is.

(Complainants offer diagram presented by witness in evidence, which is marked Exhibit X.)

Int. 59. State whether or not, after making this sketch, you showed it to Mr. Pope.

Ans. I did.

58 Int. 60. After showing this to Mr. Pope, did you make any drawing or diagram of an improvement in the instrument or instruments by which Mr. Pope's system was to be worked?

Ans. I did.

Int. 61. Have you that here?

Ans. I have.

Int. 62. Show it, please.

Ans. I have it here.

(Copy to be made and put in evidence; original and copy to be marked Exhibit Y.)

Int. 63. Have you another diagram, made by you about this time,

or a few weeks after, representing the perfected machine outlined in Exhibit Y.

Ans. I have. This is it.

(Witness presents diagram, which complainants place in evidence, and which is marked Exhibit Z.)

Int. 64. Did you show Exhibit Z to Mr. Pope, and when?

Ans. I did; December 3, 1872.

Int. 65. Whose handwriting is that pencil-mark on it, "S. C. H., Dec. 3, 1872"?

Ans. Mr. Pope's.

Int. 66. Was a patent afterwards taken out for that?

Ans. There was.

Int. 67. Have you it, or a copy of it?

Ans. I have.

Int. 68. What was its number and date?

Ans. No. 143,694, dated October 14, 1873, issued to S. C. Hendrickson. The application was filed December 26, 1872.

Int. 69. Have you a model of that machine?

Ans. I have.

Int. 70. Will you please produce it?

Ans. Yes; here it is.

(Witness produces model, which complainants place in evidence, and which is marked Exhibit AA.)

59 Int. 71. When did you construct that model?

Ans. In December, 1872.

Int. 72. State whether or not the invention described in the diagram, patent, and model last referred to was made with a view to aid the working of Mr. Pope's system; and, if so, in what manner?

Ans. It was, as I thought, that more signals of this description could be worked from one battery, than of the signal previously in use.

Int. 73. If I understand this model, in one respect it indicates signals to be worked by machinery controlled by electricity instead of working them by electricity without the aid of machinery. Am I right?

Ans. You are right.

Int. 74. Is that part of it new?

Ans. I considered it new at that time.

Int. 75. Please state concisely the manner in which this improvement, which you then considered new, would aid Mr. Pope's arrangement by working more signals with one battery than could have been worked with the old signals?

Ans. It would be much easier to release the hook from detent or detents on shaft, and the displaying of the signal-disc was caused by the weight of the signal, taking less power to release than in the old pattern.

Int. 76. What is the small detached figure on the margin of Exhibit X?

Ans. It represents one of the signals as used by us on the Boston and Lowell road.

Int. 77. You speak in your previous answers of the former pattern and the old signals; state whether or not you refer to those of this pattern or Exhibit X?

Ans. I refer to one of this pattern, Exhibit X.

Int. 78. Have you read, or partly read, Mr. Morton's testimony in this case?

Ans. I have merely glanced at it to-day; this is the first time I have seen it; I was not present at the taking of it and did not hear it given.

Int. 79. In the answer of Mr. Morton to cross-interrogatory
60 43 he says: "The description is quite sufficient to enable any one skilled in the art to do the thing described, but I do not believe that when this was done it would produce the desired effect, if by that you mean the production of a successful permanent insulation. The wear of rails on a railroad consists largely in the carrying off of minute fragments of iron of the rails; if the insulating materials were such as wood or any softer substances these would imbed themselves in it, and soon form an electric connection or conductor. If the material vulcanite were used as proposed, this would, when exposed to light, rapidly lose its insulating property on the surface, and especially in wet weather, would become a good conductor. The film of water which, during wet weather, would naturally cover every part of the track, would also form a good conductor between adjacent rails, and though, of course, this mode of insulation would work for a time and under favorable conditions, it could not be relied on under the conditions of practical use." Have you read the portions of the patent 129,425 granted to F. L. Pope, dated July 16, 1872, and marked complainants' Exhibit O, especially the second column of the second page, and also the English patent to William Robert Lake, No. 2462, dated August 19, 1872, Exhibit P, which are referred to in the foregoing answer of Mr. Morton?

Ans. I have read them.

Int. 80. Have you seen in actual operation circuit closers for electric signals which were formed of insulated sections of railroad track in the manner referred to in complainants' Exhibit A, O, and P, and which were operated by the passage of locomotives or trains over such insulated sections?

Ans. I have.

Int. 81. Will you state some of the different places where you have witnessed the operation of such circuit closers?

Ans. I have, at Bethlehem, on Lehigh Valley road; Bear creek, on the same road; at Baltimore, on the Baltimore and Ohio road; at tunnel No 3, 10 miles south of Sparta, Wis., on the Chicago and Northwestern railroad; at Milwaukee, on the Milwaukee and
61 St. Paul railroad; at East Liberty and Millvale, on the Pennsylvania railroad; on the West End railroad, within the Centennial grounds. That is all I think of now.

Int. 82. In all your experience and observation have you ever known an instance in which any such circuit-closer, where the in-

sulation was in accordance with Exhibits A, O, and P, failed to perform its function of operating the signal, either in consequence of non-insulation of the rail from the earth in wet weather, or in consequence of an electric connection being formed across the insulated joints by fragments of metal worn from the rails?

Ans. I never had any such difficulty.

Int. 83. Do you or not know, as a matter of personal observation or experience, whether an insulated section of track arranged in the manner shown and described in Complainants' Exhibit A will perform its functions and operate a signal when such insulated section is completely submerged in water?

Ans. I do know, and have seen such sections of insulated track submerged in water, and it made no difference as to impeding the working of the signal.

Int. 84. Give an instance when and where this happened.

Ans. At Bear creek, Penn., 7 miles above Mauch Chunk; at tunnel No. 3, 10 miles south of Sparta, Wis., and on the Centennial Exhibition Grounds, Philadelphia. These are all the points that I have seen.

Cross-examined by Mr. BALDWIN:

Cross-int. 85. How much do you claim Mr. Hall or his company owed you after the payment which he made you January 4, 1870, of $105.25?

Ans. I should have to refer to the letter; I made him a present of the amount, as he wrote me a letter stating that he did not owe me one cent.

Cross-int. 86. Then he claimed, did he, that he had paid you all he owed you?

Ans. All but what was due from the signals on the Flushing and North Shore road. He did state he would pay me the bal-
62 ance after the inspection of such signals at a certain day he appointed to meet me there; I mean at Flushing; I was there and waited for him, but did not see him. I returned home. I was up there a day or two afterwards, and I heard Mr. Hall had been there, and I returned home again.

Cross-int. 87. What day, month, and year were you there the first time, to which you have just testified?

Ans. I cannot tell without looking to some of my memoranda.

Cross-int. 88. What was the amount that you say you made him a present of?

Ans. The balance of the bill; more than $25.

Cross-int. 89. Did you and he ever inspect the work at Flushing after January 4, 1870?

Ans. I did not with him.

Cross-int. 90. When did you first go to Boston or East Cambridge, in the fall of 1871?

Ans. It was in November, about the 1st, I think.

Cross-int. 91. How long did you stay there at that time?

Ans. About nine or ten days.

Cross-int. 92. What were you doing during that time?

Ans. Watching and waiting to see how everything was working; and as the Western Union people were stringing wire on the route, they kept interfering with our signal wire.

Cross-int. 93. Who put up the signal apparatus there at this time on the Boston and Lowell railroad?

Ans. Mr. Pope and myself.

Cross-int. 94. How long was it after you got there before your signal apparatus was fully put up?

Ans. About four or five days; it might have been a day or two longer.

Cross-int. 95. Did you remain longer after the apparatus was fully put up and in operation?

Ans. Two or three days, to see how it worked, as I have stated before.

Cross-int. 96. When were you next there again?

Ans. I left New York on the 14th, and arrived in Boston on the 15th of November.

63 Cross-int. 97. How long did you stay at that time?

Ans. About ten days.

Cross-int. 98. When were you next there after that?

Ans. I was not there again on that business; not at the signal.

Cross-int. 99. Then you never saw this application in the Boston and Lowell railroad after about November 25, 1871, did you?

Ans. I don't recollect as I did.

Cross-int. 100. Name any day or days when you saw the apparatus on this road actually operated by trains.

Ans. This was merely done to show that it could be operated by a train, in the presence of two or three railroad men. The signal was put up to show when a train reached East Cambridge. We tried the experiment of operating it by the train one afternoon, one gentleman that I recollect by name, Mr. Parker, station agent at that (Boston) depot, being present. That is all that I recollect.

Cross-int. 101. About when was this experiment in the presence of Mr. Parker—on your first or second visit?

Ans. It was the second visit.

Cross-int. 102. And this, as I understand you, was the only time when you personally saw this apparatus in actual operation between Boston and East Cambridge?

Ans. I would state that I had seen it in operation on previous occasions by the train releasing the signals, at East Cambridge, which is an equivalent to setting the signal, as the same relay both closed the circuit or opened the circuit, as shown in diagram Exhibit W, fig. 1, releasing signal; also in fig. 2, for displaying signal.

Cross-int. 103. Did you ever see this apparatus so operated as to display a signal except the time you have mentioned, when Mr. Parker was present?

Ans. I had merely tried the experiment by myself, before and afterwards.

Cross-int. 104. Do you recollect any railroad man, except Mr. Parker, in whose presence this apparatus was put in operation?

Ans. Gentlemen who represented themselves to be railroad

64 men were witnessing the operation of the signal daily while I was there.

Cross-int. 105. Do you refer to its operation in displaying or releasing a signal?

Ans. Releasing. The displaying was done principally by the ticket agent as the train left Boston.

Cross-int. 106. Did you ever see the ticket agent display the signal, except on one occasion?

Ans. I did, on a great many occasions; every train.

Cross-int. 107. For how many days?

Ans. I suppose about 15 days; the time that I was there.

Cross-int. 108. How did the experiment in the presence of Mr. Parker differ from these other experiments to which you have just alluded?

Ans. They were about the same.

Adjourned to Feb. 12, 1879, 10 a. m.

Deposition of Frank L. Pope.

HARTFORD, *February* 12, 1879.

Met pursuant to adjournment. Parties represented as heretofore.

F. L. POPE, recalled:

Int. 1. You stated in your answer to int. 1, in your direct evidence, that letters patent 140,536, dated July 1, 1873, were issued to you; please state when you invented the improvements and combinations described in those letters patent and the specifications therein, giving the date and history of your first intellectual conception of the invention, and such preliminary, subsequent, and accompanying history as will throw any light on the invention, or establish the important dates connected with its history while you were perfecting it?

Ans. My attention was first called in any way to the subject of electric signals for railways in the year 1867, to the best of my recollection. I was at that time employed as super-
65 intendent of a telegraph for reporting the quotations of prices of gold, which was worked in connection with the Gold Exchange in New York city. I was also at that time editor of The Telegrapher, a weekly journal devoted to telegraphic and electrical news. At the time of which I speak I received an invitation to attend a lecture on this subject, to be given by Prof. R. O. Doremus, at what is now the College of the City of New York. I attended this lecture, and among the electrical apparatus which was exhibited and explained by the lecturer was an electro-magnetic signal apparatus, which was stated to be the invention of Mr. Thomas S. Hall. This apparatus was explained in detail by the lecturer, and its operation exhibited in connection with railway switches and drawbridges.

This idea was then entirely new to me, and as an electrician I was much interested in it. At the close of the lecture I either introduced myself to or was introduced to Mr. Hall (who was present at

the lecture), and had some little conversation with him in relation to his invention, with a view of preparing a notice of it for publication in my paper, which notice I afterwards prepared and published.

I remained in charge of the Gold Reporting Telegraph until about August 1, 1869, but relinquished the editorship of The Telegrapher, I think early in 1868. During the year 1868 I wrote the book entitled Modern Practice of the Electric Telegraph, an extract from which has been put in evidence, being complainants' Exhibit K.

About the 1st of October, 1869, I commenced business on my own account as an electrician and telegraphic engineer, and hired an office in room 48 of the building Nos. 5 and 7 New street, New York city.

Soon after commencing this business I invented an instrument for printing the prices of gold, and thus preserving a permanent record, instead of merely indicating them, as had been previously done, on a dial.

This invention was successful, and within a few months went into very extensive practical use. Early in the spring [of 1870] it was purchased by the Gold and Stock Telegraph Company and passed from my control.

66 It then occurred to me that by attaching to this instrument a peculiar electro-magnetic movement which I had conceived of about that time, a very simple and effective printing telegraph, well adapted for use on private lines, could be made, which could be operated by anybody.

I associated others with me in this enterprise, and procured a license from the Gold and Stock Telegraph Company to use the original invention, and immediately commenced the manufacture of printing telegraph instruments.

About the month of March, 1870, I placed this invention of the electro-magnetic movement in the hands of a solicitor for the purpose of having an application for a patent prepared. While engaged in preparing the specification the solicitor, Mr. M. M. Livingston, advised me to suggest any other practical applications of the inventions other than to printing telegraphs which might occur to me.

I suggested, in accordance with this, that it might be used to operate electric railroad signals at a distance, for the reason that either one of two different signals might be exhibited at any distance, or two diverse operations of any sort performed by the use of a single wire, in accordance with the principle of the invention.

A paragraph to this effect was incorporated in the specification. This patent was issued May 17, 1870, and was numbered 103,077. During the entire year 1870 we were engaged in manufacturing and selling printing telegraph instruments under this patent.

Among others we sold a number of them to the Flushing and Northside Railroad Co., of Long Island, and I myself attended to placing them in the stations along the line of the railroad, and in instructing the railroad employees in their use.

While thus engaged on this road I witnessed the operation of some of Mr. Thomas S. Hall's signals and alarms, which were placed at some of the highway crossings, and set in operation by the approach

of a train to the crossing. I examined only the track circuit-closers and the exterior of the signal-houses, and did not see, nor in any way acquire any knowledge of the construction and arrangement of the machinery inside of the signal-houses.

67 During that same summer, in July or August, 1870, prompted merely by scientific curiosity, I made an experiment on the line of the New Jersey Railroad & Transportation Co., between Elizabeth and Rahway, N. J., for the purpose of ascertaining whether it was possible to use the rails of the track as a telegraphic conductor, my idea being that according to calculation the iron of a railroad track, owing to its much greater size, would be nearly 400 times as good a conductor as an ordinary telegraph wire, and consequently would admit of 400 times the amount of leakage of current per mile, in consequence of imperfect insulation, without interrupting the working. The experiment proved that this was the case, at least to a considerable extent, as I succeeded in telegraphing a distance of two or three miles through the track with a common telegraphic sounder and a single cell of battery. Soon after making this experiment, I told Mr. Livingston about it, and he advised me strongly to take out a patent on it. I told him I could see no practical application of the fact that I had discovered, and until I did, I should not trouble myself about a patent.

About this time, that is to say, in the summer or early autumn of 1870, on getting off the train from New York, one day, at Hartford, Conn., I met Mr. Thomas S. Hall, who was about to get on to the same train to go north; I believe that this was the first time I saw him after the time when I met him at the lecture, as before stated. He said to me in a jocular sort of way: "So you are going into the electric railroad signal business, are you?" and I answered in the same spirit, saying: "Oh, yes; I am going into all kinds of electrical business." It did not then occur to me that he meant anything serious by his remark, as I had not up to that time entertained the remotest idea of doing so. I only saw him for a few moments at that time, and we had no further conversation of consequence. It afterwards occurred to me that Mr. Hall's remark probably had reference to the paragraph about railroad signals, in my patent of May 17, 1870.

68 In the spring of 1871 the Gold and Stock Telegraph Company opened negotiations with us for the purchase of our private line telegraph business, patent interests, etc., which we had pushed energetically and in which we were very successful, but were much hampered for lack of capital to carry on properly. While these negotiations were pending Mr. Walter O. Lewis, a mutual friend of myself and my partner, Mr. J. N. Ashley, called in our office one day, to the best of my recollection, not far from the 1st of May, and invited us to go over to his office, which was situated over Delmonico's restaurant, in the building No. 22 Broad street, New York city, to examine a working model of an electric railroad signal which he had on exhibition there, and which he stated was the invention of Mr. S. C. Hendrickson. We went to Mr. Lewis' office that same day and there met Mr. Hendrickson, and I had some conversation with him about his invention. This was the first conversa-

tion I ever had with Mr. Hendrickson on this subject. Within a very few days Mr. Hendrickson called on me at my office and requested me to assist him in relation to his patent for his signal, he knowing that I had had some experience in taking out patents. He had already filed an application, which had been rejected. I took charge of his application and succeeded in securing a patent therefor, which was issued and numbered 115,610. The drawing attached to this patent is a correct representation of the working model of this invention that I saw in Mr. Lewis' office. While engaged in attending to this matter for Mr. Hendrickson we had considerable conversation about the general subject of railroad signals, in which Mr. Ashley took part, and which ultimately resulted in a business arrangement (first proposed by Mr. Ashley), by which Mr. Hendrickson, Mr. Ashley, and myself formed a copartnership for the purpose of practically introducing Mr. Hendrickson's invention. This arrangement went into effect in June, 1871, previous to which we had disposed of our printing telegraph interests to the Gold and Stock Telegraph Co., leaving us free to engage in the new enterprise.

At the time of making this arrangement I personally had no knowledge of Mr. Hall's inventions or operations other than
69 I have already mentioned. When Mr. Hendrickson entered into this arrangement his only inventions, so far as I have any knowledge, consisted of the signal before mentioned, an alarm-bell operated by a revolving electric motor, a track-lever circuit-closer, a double-acting relay by means of which the track-lever was made to act upon the signal and alarm, and a circuit-closer designed for attachment to a switch or drawbridge. He brought models of all these arrangements which he had previously made. I immediately set to work and prepared an application for a patent on these various devices of Hendrickson's, in the course of which I introduced one or two modifications of my own, of no great importance; but in consequence of these modifications Mr. Livingston advised that the patent be taken out in our joint names, which was accordingly done.

This application was filed in July or August, 1871, and the patent thereon issued July 16, 1872, and was numbered 129,408.

In the course of the conversations with Mr. Hendrickson, during the few weeks prior to the consummating of the business arrangements above referred to, it had occurred to me that the fact that I had discovered in the course of my experiment on the N. J. R. R. the previous summer might be utilized as a method of operating an electric signal by the passage of moving trains. I made some further experiments in my office, including tests by means of the galvanometer, of the conducting properties of water and of pieces of wood saturated with water, the result of which was such as to convince me of the entire practicability of the scheme, provided the proper precautions were used in respect to the proportionate electrical resistances of the battery, the electro-magnet, and the connections from them to the rails. This information I communicated to Mr. Hendrickson after the business arrangement between us had been closed. As I had no desire whatever to interfere with Mr.

Hall's enterprises, I suggested to Mr. Hendrickson that we had better devote our attention to the invention of an automatic block-signal system, or rather what has since come to be called by that name—that is to say, a system for preserving intervals of
70 space between trains travelling in the same direction. Such a system of space signals was already in practical successful use at that time on the line of the N. J. R. R. I was perfectly familiar with the system then used, and with its great practical value, and it at once occurred to me that if the operation could be made automatic, and the services of two telegraph operators at every station dispensed with, that it would be an improvement of very great value. I did not at that time know that Mr. Hall had turned his attention to the solution of the same problem, and I first learned of the fact by reading a description in one of the New York daily papers of his signal system on the Harlem R. R., in New York city, which, to the best of my recollection, was some time in the fall of 1871. In the early part of September, 1871, I prepared an application for a patent on my system of track circuit-closers in connection with signals, which was filed on the 19th of September, 1871, and patented on the 16th of July, 1872, No. 129,425.

After this application was filed, I went for a couple of weeks' vacation to York, Me., and while there met Mr. Moses G. Farmer, who was boarding in the same neighborhood. Mr. Farmer being one of the best informed electricians in America, I explained my plan of working signals to him, to see what he thought of its practical utility. His reply encouraged me very much, as he told me he had no doubt that it would work well in practice if the proper conditions were observed; the conditions referred to by him being the same as I have heretofore stated. He advised me to make an actual trial of the invention on some railroad, and to spend some months, or years, if necessary, in observing its action under various conditions, and finding out and remedying the various difficulties that would be sure to arise from time to time. He told me that he had spent several of the best years of his life in doing the same thing with the fire alarm telegraph before it could be relied on as an entirely successful arrangement. He also, upon my departure, kindly offered to give me, and did give me, a letter of introduction to Mr. George Stark, general manager of the Boston, Lowell & Nashua
71 railroad, who, he said, was a personal friend of his, in which letter he requested him to afford me any facilities he conconveniently could for making my experiments on his road if I wished to do so.

The first week in October, 1871, I left York and went to Boston, and presented my letter to Mr. Stark, who at once gave me permission to experiment to any extent I pleased on his road, at the same time remarking that if I developed anything of practical value he had no doubt the corporation he represented would be glad to adopt it. After this interview I returned to New York city, and had a consultation with my partners, the result of which was that we decided to make a practical application of the invention.

Owing to the peculiar construction of the track of the Boston,

Lowell & Nashua railroad, the two rails being tied together with iron rods at short intervals, it was impossible for us to make use of the precise arrangement which I had originally designed to do, and which is shown in my patent No. 129,425, and I therefore invented a modification of this system, which was successfully applied, being that represented by Exhibit W.

During the greater part of the month of October, 1871, I was engaged in the superintendence of the construction of apparatus to be used in this application. The machine for exhibiting the signal, which was constructed at that time, and in accordance with my directions and designs, I have here with me, and I here produce it.

(Complainants place the instrument shown in evidence, which is marked Exhibit B B.)

It is a modification of the original signal machine invented by Hendrickson before I became connected with him; the modifications being of my own invention, and consisting of the introduction of a wheel or roller at the end of the levers acted upon by the magnets, which rollers act directly upon the spiral screw-thread or track upon the upright signal shaft, thus dispensing with the compound lever and toothed segment originally employed by Hendrickson; and also in the adddition of a spring detent or lock acting directly upon the signal shaft, and serving to keep the signal exhibited after the electric circuit though the main magnet or
72 magnets has been interrupted; together with an independent electro-magnet in another circuit, which, when brought into action by an electric current, withdraws the detent or locking device, and thus permits the signal to be concealed by the action of a spring. The last week in October, 1871, I went to Boston, accompanied by Mr. Hendrickson, for the purpose of setting up and putting in operation our signal apparatus on the Boston, Lowell & Nashua Railroad. We spent a day or two looking over the ground, and I finally decided to arrange the apparatus in the manner shown in the diagrams, Figs. 1 and 2 of Exhibit W. After the plan was decided upon Mr. Hendrickson drew a sketch of it in his note book and proceeded to put up the apparatus in accordance therewith. The signal machine, Exhibit B B, which I have already described, was placed in a suitable case upon the top of the ticket office of the Boston station, and the signal was arranged to be exhibited by the action of a local battery upon its electro-magnets whenever the circuit of said battery was closed by means of a hand key in the ticket office. An electric gong or bell was also placed in this electric circuit. At a point opposite the station in East Cambridge, a mile or two from Boston station, a section of the right-hand rail of the outward bound track, forty-two feet in length, was insulated from the adjacent line of rails in each direction. This was accomplished by removing the iron fish-plates from the joints at the end of the insulated section and replacing them with heavy pieces of oak wood, which were bolted to the rails to keep them in line. Wedges of hard wood were also inserted between the abutting ends of the rails at the insulated joints. The track at this point was ballasted with

ordinary earth or gravel filled in even with the upper surface of the ties, and beaten down hard by persons continually walking over it. A relay consisting of an ordinary telegraphic sounder, altered over for this purpose, was placed inside the station, and one wire of its electro-magnet connected to a battery and a wire connected from the other end of the battery to the insulated section of the track. The other wire of the electro-magnet of the relay was connected by a wire to the opposite insu-
73 lated rail. The first plan of operation which we adopted was that shown in Fig. 1, Exhibit W. The relay of which I have just spoken, when operated, closed the circuit of a secondary battery, and transmitted an electric current therefrom through an ordinary telegraph wire, which ran upon the poles of the Western Union Telegraph Co., from East Cambridge to Boston, and thence through the releasing or reversing magnet of the signal over the ticket office in Boston, and thence to the earth, which was employed instead of a return wire to East Cambridge. When thus arranged the operation was as follows: At the departure of each outward bound train from Boston, the ticket-agent would depress his key and close the circuit of his local battery long enough to bring the signal into a position at right angles to the track, indicating that the track was occupied. After he had released the key the signal was held in this position by the detent previously described, and remained in the same position until the engine of the outgoing train passed over the insulated portion of the track at East Cambridge, closing the circuit of the relay at that point, and causing a current to be transmitted back to Boston, which acted on the releasing or reversing magnet of the signal, causing it to unlock the detent, upon which the signal returned to its normal position. The person whose business it was to start the trains from Boston was thus notified that the track was clear as far as East Cambridge. The apparatus was completed and put in operation in the manner I have just described on 9th day of November, 1871.

I remained in Boston about ten days after the apparatus was put in operation, for the purpose of watching its performance, explaining it to visitors, and making various experiments in connection with it. Among other experiments, I changed the electrical connections of the wires at the Boston signal to correspond with the diagram Fig. 2, Ex. W, in which the independent magnet for releasing the locking device is made to serve as a relay, it having been constructed in such a manner as to admit of this modification. The object of this change was to reverse the action of the appa-
74 ratus, so as to enable the signal to be displayed or exhibited by the passage of a moving train over the track circuit-closer at East Cambridge. I will here remark that this insulated section of track was purposely made long enough, so that the circuit would remain closed while the entire train was passing over it, thus giving plenty of time to swing into position, even though that operation might require several seconds. During my stay in Boston at this time I several times arranged the apparatus to work in this way,

and once at least for the purpose of exhibiting the operation to some railroad men.

Another experiment which I made within a few days after the signal was first put in operation was for the purpose of testing the degree of insulation of the track circuit-closer at East Cambridge. This test was made in the afternoon of a day when it had been raining very hard for several hours, the space between the rails in front of the station being covered two or three inches deep with standing water, which came above the base of the insulated rails. The instrument used was Siemens' universal galvanometer. The insulation resistance of the insulated section of rail under these conditions measured 197 electrical units. About the 20th of November, 1871, I was obliged to return to New York city to give testimony in a suit, and afterward to go to Michigan on personal business. I left the apparatus in Boston in successful operation, and arranged with a person there to renew the batteries when required, and to remove any interruptions which might be caused by the Western Union Telegraph wires (which were being rebuilt between Boston and East Cambridge) getting in contact with the signal wire. I also made an arrangement with one of the employees of the railroad company to report any such interruptions that they might be remedied. This apparatus was in continuous operation, with the exception of occasional interruptions from the causes mentioned, until the latter part of February, 1872.

We were then informed by the railroad officials that the Boston station was to be removed to make room for a new building, and that all the tracks, bridges, etc., between Boston and East
75 Cambridge were to be removed and to be rebuilt in a different location, and that the operations would not be completed before the following fall. For this reason we concluded to have the apparatus taken down and stored, intending to re-erect it again at some future time.

The apparatus and system which I have described, and which was thus operated from the 9th of November, 1871, to the latter part of February, 1872, contained two of the essential elements of the combination afterwards patented by me in patent 140,536, Complainants' Exhibit A, viz: A circuit-closer, which, when operated by a railroad train moving at any practicable rate of speed, will remain closed long enough for a signal-disc to be moved into position by the action of an electro-magnet, even if the operation requires several seconds, as is the case when a small battery power is used; also, a signal-disc provided with a lock or detent for holding the disc in position after the electric circuit which has brought the signal into position has been interrupted, and an independent magnet for unlocking the said detent and releasing the signal when actuated by an electric current transmitted from the next signal station in the series.

During the time in which this signal was being exhibited by me in November, 1871, it was examined by a considerable number of railroad men. Some of these gentlemen, in criticising the apparatus, said that it would be an important improvement in it if it could be

arranged to show a double signal—that is to say, two white lights side by side to indicate safety, and two red lights arranged in the same manner to indicate danger, giving as a reason that a pair of white lights was likely to be less confounded with any other accidental white light which might be exhibited in a dwelling-house, for example, near the line of the railroad, and, also, that when the two lights were exhibited the chance of both being accidentally extinguished would be less than in the case of a single light. Acting on this suggestion, immediately after my return from Michigan, which was in the early part of December, probably about the first of the month, I made drawings of a new signal machine and placed
76 them in the hands of L. G. Tillotson & Co., of New York city, with directions to construct one for me as soon as possible. During the month of December much of my time was taken up in superintending the construction of these signals, which, like all new mechanism, required consideral alteration from the original plan. It was, however, completed and delivered on the 2d of January, 1872.

This machine was in all essential particulars exactly like that represented in Fig. 1 of the drawings of English patent of W. R. Lake, Exhibit P, the only difference being that, as originally constructed by Tillotson, it was provided with a detent and independent releasing magnet, upon the same principle as Exhibit B B. I experimented considerably with this machine during the month of January, and had some alterations made in the mechanical details of it—the leverage of the moving parts, etc.

Having finally got it so that it worked to my satisfaction in the office, Mr. Ashley gave Tillotson & Co. an order to construct six more signals of the same model. All these were arranged to show a double signal. Some time during the month of February, 1872, Mr. James A. Whitney, secretary of the New York Society of Practical Engineering, called on me one day and said that he had seen a notice of my electric signal apparatus at Boston, in some newspaper, and asked me if I was practically acquainted with the general subject. I told him I was to some extent, and he then requested me to prepare a paper on this subject, to be read before his society.

I consented to do this, and thereafter, so far as my other duties would allow, I spent considerable time in informing myself in respect to the state of the art up to that time. I procured copies of the patents of Mr. Thomas S. Hall, Mr. Wm. Robinson, and others, and visited and examined for the first time the system which had been put up by Mr. Hall or under his direction, between Forty-sixth street and Harlem river, on the Harlem railroad, in New York city. This paper was completed by me and read before a meeting of the Society of Practical Engineering in New York city, on the
77 evening of the 13th of March, 1872. It was immediately afterwards printed in full in the Railroad Gazette, the American Artisan, and some other professional journals, whose names I do not now recall.

The copy of this paper put in by defendants as Exhibit I, I should judge to be a correct copy of the paper at that time read by me.

Within two or three weeks after the publication of this paper Mr. Frank Thomson, then superintendent of the eastern division of the Philadelphia and Erie railroad, called upon me with reference to fitting up a section of single track between Northumberland and Sunbury, Penn., with some sort of a system of signals, and the result of the interview was a request from Mr. Thomson to come to his headquarters at Williamsport, Penn., at my earliest convenience, to look over the ground and consult with him and other officers of the road as to the best arrangement to be adopted.

I accordingly went to Williamsport, within a few days, and remained there several days, in consultation with the railroad officials. Mr. Thomson was not disposed to favor the use of automatic signals, but preferred a modification of the English plans. The final result of the conference was that I designed a plan for working the semaphoric signals at each end of the single track by the operators in the telegraph office, which met with Mr. Thomson's approval, and which was subsequently carried into execution. This plan is correctly represented by letters patent No. 130,941, granted to me August 27, 1872.

It does not, however, contain any of the elements of the combination set forth in my patent, Exhibit A. It was put in operation, I think, in June, 1872, at Northumberland and Sunbury. About the middle of June, or within a few days after that, I received a letter from Mr. A. J. Cassatt, then general manager of the Pennsylvania railroad, requesting me to bring my plans, models, etc., of signal apparatus to Philadelphia, and exhibit and explain them to him at his office. In compliance with this request I prepared the necessary drawings, and in the latter part of June, about a week
78 before the 4th of July, I went to Philadelphia and explained the whole matter to Mr. Cassatt. The result of this interview was a proposition from Mr. Cassatt to me to make a trial of our apparatus at some suitable point on the Pennsylvania railroad, he agreeing to divide the expense of the experiment or trial with us in case the apparatus did not prove satisfactory, and stating that he thought the company would be glad to adopt it if it answered the purpose. Myself and partners agreed to this proposal, and on the 29th of July, 1872, Mr. Hendrickson and myself went to Pittsburg, at which point we had been instructed by Mr. Cassatt to report to the division superintendent, Mr. Robert Pitcairn.

Mr. Pitcairn decided to fit up one track of the road (the westbound track), between the outer depot at Pittsburg and the stockyards at East Liberty, with a series of automatic block signals, and instructed us to go on and put them up as soon as possible, and to call on him for any labor, materials, or assistance required in the prosecution of the work. Accordingly, Mr. Hendrickson and myself, with the assistance of a number of railroad employees, insulated short sections of track at Lawrenceville, Millvale, Shady Side, and Roups stations. These stations are situated perhaps a mile apart, between the outer depot at Pittsburg and East Liberty.

We had at that time but three available signal machines, and these were placed at Millvale, Shady Side, and Roups. The batteries

for operating them were placed in the respective station-houses, each signal being provided with its own system of batteries and circuits.

The signal machines used at these places were precisely like that represented in fig. 1 of Exhibit P.

The mechanical locking device and independent magnet for unlocking the same was dispensed with in these instruments. After the signal had been brought into position by the action of the electro-magnet, it was held there after the circuit was interrupted by the residual magnetism of the main magnet, which was retained therein by the device of allowing the armature to come in direct contact with the poles of the magnet.

79 Therefore, after the circuit was interrupted, the armature still continued to adhere to the magnet and hold the signal displayed until an electric current of reverse polarity was transmitted from the next station in the series, when the residual magnetism would be neutralized or discharged, and the armature thrown off or released, permitting the signal-disc to return to its normal position by the action of a counter-balance or weight.

Mr. Hendrickson assisted me for some days in putting up this system, but returned to New York on the 9th of August, having undertaken to construct a telegraph line on Long Island.

I remained and completed the work and set the signals in operation, and stayed several days watching them after they had commenced to work. The last week in August I was notified by Mr. Livingston that it was necessary that the specifications for our English patents should be prepared at once in order that our rights might not be forfeited, and accordingly I returned to New York and spent most of the first two weeks of September in preparing the drawings and specifications of the English patents. The signals between East Liberty and Pittsburg were first put in operation about the 15th of August, 1872.

I will now briefly describe the manner of their operation:

When a westward-bound train leaving the stock-yards at East Liberty passed over the insulated section of track forming the circuit-closer near Roups station, it closed the circuit of a battery which actuated a relay in the signal-box, which contained the signal, and was placed upon a post at the right-hand side of the track. This circuit remained closed while the entire train was passing over the circuit-closer.

The relay brought into action another battery, which vitalized the signal magnet, and thus caused the signal to be exhibited.

After the train had passed by both these circuits were broken, but the signal remained exhibited on account of the armature adhering to the magnet by the force of the residual magnetism. When

80 the train, in the course of its westward progress, reached Shady Side, the next station, the same operation was repeated, the arrangements at that point being precisely similar to those at Roups, with the addition of a branch circuit from the same battery which actuated the main signal magnet, which branch circuit was closed by the contact points of the Shady Side relay at the same time as the signal circuit.

This branch circuit extended back to the main signal magnet at Roups, and passed through its coils in the reverse direction to the current which had caused the signal to be exhibited, discharged or neutralized the residual magnetism, and released the signal-disc.

Therefore the passage of the train over the circuit-closer at Shady Side actuated the relay at that point, and the closing of the contact points of this relay simultaneously exhibited the signal at Shady Side and concealed the signal at Roups by the direct action of one and the same battery.

This operation was again repeated when the train reached Millvale, the reversal of the Millvale signal being effected by a special circuit-closer and a battery at Lawrenceville.

I will prepare a sketch of the signals and their connections as arranged at Roups and Shady Side and put the same in evidence as an exhibit.

The operation of this system of signals was for some days entirely satisfactory. During the latter part of August it was inspected and tested by means of a special train accompanied by a considerable number of superintendents of various divisions of the Pennsylvania railroad, and operated to their entire satisfaction. Just prior to my departure for New York, about the end of August, I noticed that the mechanical portion of the signal machinery showed a tendency to operate imperfectly, and an investigation into the cause of this convinced me that it was owing to the violent shocks which were communicated to the moving parts of the machinery when the armature of the main magnet to which they were attached came in contact with the pole or poles of the magnet; the attraction exerted just at the end of the stroke being very powerful. Before leaving
81 I informed the chief operator of the telegraph department, who was left in charge of the signal system, that I did not think that the machines we had placed there would continue to work satisfactorily for any great length of time, and that I would construct some on an improved plan, avoiding the difficulty I have mentioned.

Adjourned to February 13, 1879, 10 a. m.

HARTFORD, *February* 13, 1879.

Met pursuant to adjournment.

Parties present as heretofore.

Evidence of F. L. POPE resumed:

The arrangement for insulating the joints of the rail, which was employed in connection with the system last described, was substantially similar to that which I had previously employed at East Cambridge, and is correctly represented in fig. 6 of the drawing attached to Exhibit P, with the addition of a wedge of hard wood, which was driven in between the ends of the abutting rails.

I wish to make a correction in my testimony given yesterday. I stated that "the last week in August I was notified by Mr. Livingston that it was necessary that the specifications for our English patents should be prepared at once," and also that I "spent most of

the first two weeks of September in preparing drawings and specifications of the English patents."

By referring to my memoranda I find that I have partially confounded this with another transaction.

Mr. Livingston requested me to return to New York the last week in August, 1872, as I have stated, but it was in reference to a different transaction, which only occupied me for a day or two.

On the 29th of August I left New York and went to Sun-
82 bury, Penn., to remedy some difficulty which had occurred with the signals there; I think some trouble with the batteries.

On the afternoon of September 1 I left Sunbury and went by Lewistown and Pittsburg to Cincinnati, O., where I arrived on the afternoon of September 2. I remained in Cincinnati between one and two weeks, during which time I was engaged in setting up and exhibiting our signal apparatus in the Cincinnati Industrial Exhibition, after which I returned to New York. Immediately after returning home I went to work making plans for a new signal machine which was intended to obviate the practical defects which had manifested themselves on the Pennsylvania railroad near Pittsburg. I was engaged on this work and in making experiments in connection therewith until about the middle of October. The first improvement which I made, during this time was intended to obviate the sudden and violent shock of the armature against the poles of a powerful magnet when fully charged, and which experience had shown to be very damaging to the signal machine. I succeeded in remedying this by attaching to the lever which formed the mechanical connection between the armature and the signal-disc, a cut-off or circuit-breaker which interrupted the circuit through the main magnet before the completion of the stroke, leaving the signal to swing into position after this circuit was broken by the momentum which it had already acquired.

This cut-off was made adjustable so that it could be arranged to suit varying circumstances in respect of strength of battery, weight of signal-disc, etc. This change, of course, rendered it impossible to depend on the residual magnetism of the main signal magnet to hold the signal-disc in position, as had previously been done. I therefore resorted to the device of placing a small armature upon the signal-disc itself in such a position that when the disc was fully displayed by the action of the main magnet and its acquired momentum, as before explained, this small armature would be brought into contact with the poles of an independent magnet placed in a proper position to receive it. The cut-off device before re-
83 ferred to was so arranged as to transfer the current of the battery to the independent magnet after it had been cut off from the main magnet.

After the circuit of the battery had been entirely interrupted, as by train passing off from the track circuit closer, the disc would still be held in its displayed or exhibited position by the residual magnetism of the independent magnet upon the same principle that it had previously been done by the main magnet. I tried this device

experimentally, and found it answered its intended purpose admirably. Immediately after this, that is to say about the middle of October, 1872, still another device suggested itself to me in connection with this improvement.

When the signals on the Pennsylvania railroad were inspected by the officers of the company, soon after they were put in operation in August, 1872, as I have before stated, some one of these officers—I think Mr. Cassatt—suggested that it might be advisable to arrange a secondary or, as he called it, a "tell-tale" signal in such a position as to indicate to the engineer that the primary signal had performed its office properly. It now occurred to me that such a secondary signal might be included in the same circuit with the independant or locking magnet of the primary signal, and placed at a point on the road some distance ahead of the primary signal, its normal position indicating danger or caution, and its displayed position indicating safety. Thus the same battery current, after actuating the primary signal, would be automatically switched off when no longer required for this purpose, and made to operate the secondary signal, while at the same time it would be impossible for the secondary signal to indicate safety unless the primary signal was in a position indicating danger, thus forming a perfect safeguard against any danger to trains resulting from the primary or danger signal failing to perform its function. An experimental trial of this idea with such apparatus as I happened to have at hand in the office, demonstrated to my mind its entire practicability. This in turn suggested another application of the same cut-off device, which was to make use of it to repeat the indications of a distant signal back over the same wire which was
84 employed to transmit the electric current for operating the signal, an operation which had hitherto required a distinct and independent wire. After experimentally testing this device, I prepared an application for a patent thereupon, and at about the same time completed the necessary drawings and placed them in the hands of our machinist, Mr. Unger, to enable him to construct a signal to replace the ones we already had in use near Pittsburg, and which should embody the improvements I have detailed. On the 23d of October, 1872, I went to Washington, D. C., carrying with me the application for a patent on the device for repeating back the movements of a signal on the same wire, which I had prepared, as above stated, and filed the same in the Patent Office, on the 24th of October. This was patented July 15, 1873, being No. 140,790. I remained in Washington not more than two or three days, and proceeded thence to Sunbury, Penn., by the way of Baltimore and Harrisburg, for the purpose of making some alterations in the position or in the location of the signal apparatus there. After arriving there, I found that the work would require the assistance of another man, and I therefore telegraphed to Mr. Hendrickson, who was then at Bethlehem, Penn., engaged in putting up a signal for exhibition to the officers of the Lehigh Valley Railroad Company. Mr. Hendrickson came over from Bethlehem, by the way of Penn Hayen and Hazleton. We were together in Sunbury and Northumberland

several days, engaged in making these changes which had been requested by the railroad people, and finished the work on the afternoon of the 5th of November. On the morning of the 6th of November we left Sunbury and went over to Bethlehem by the way of Hazleton, arriving about noon, or a little before.

I remained there some hours, examining the work that Hendrickson had been doing, and that same evening we went home in the same train, by the Central railroad of New Jersey. I got off at Elizabeth, and Hendrickson went on to New York.

It was during the time we were at Sunbury and Northum-
85 berland, during the week prior to November 6, 1872, that I first described to Hendrickson a plan which I had conceived, of working a series of signals along the line of a railroad in the manner we had been doing near Pittsburg, by the use of a single battery to operate the whole series. I cannot now state precisely when I conceived of this idea, but it was suggested to my mind by the device which I have already explained, whereby a primary and secondary signal were operated in succession from the same battery. As the signals in such a series are necessarily operated successively, and only one at a time, the suggestion occurred that the current of a single battery might be transferred from one to another as required, in something the same way as in the device already mentioned. I do not recollect with what degree of detail I explained this to Mr. Hendrickson at the time I have stated. Near the end of November, 1872, Mr. Unger completed and delivered the first signal machine, embodying the improvements which I had invented in October. On the 3d of December, 1872, Mr. Hendrickson showed me a rough drawing of an improved signal machine which he had devised, in which the disc was moved by means of a weight and clock-work, which was controlled by two independent magnets working alternately upon an escapement. He stated that he thought that this machine would be well adapted to be used in connection or combination with the plan I had already described to him of working a number of signals from one battery, for the reason that the greater part of the work being done by the weight, a very small electric power compared with that we had used in our previous machines would be sufficient to operate it, and consequently more signals could be worked from one battery, or signals could be worked at a much greater distance from the battery. This idea of Mr. Hendrickson's struck me very favorably, and I told him to prepare a working model at once, so that I might prepare and file an application for the same. Mr. Hendrickson thereupon proceeded to construct such a model, said model then constructed being the identical instrument (Exhibit AA). This was tested and found to work admirably, and I immediately pro-
ceeded to prepare an application for a patent, which was filed in
86 the Patent Office on the 26th of December, 1872, and patented on the 14th of October, 1873, being No. 143,694. As this signal was equally well adapted to be used in connection with the system of circuits which we already had in operation on the Pennsylvania railroad and on the Lehigh Valley railroad at Bethlehem, I described in the specification the signal as working in a system of this

description, making no allusion to the proposed plan of working a number of them from a single battery, as the particular arrangements of circuits had no necessary connection with the features of the invention which were considered to be new, and which were intended to be covered by the claims. I intended to take out a separate patent on this system of circuits after I had had an opportunity to test it, and therefore did not wish to make any disclosure of it in the specification of the patent of another inventor. During the latter part of November and the early part of December, 1872, I was also engaged in the preparation of an application for letters patent intended to embody the improvements which I had made in the machinery and system which we had placed on the Pennsylvania railroad; that is to say, the independent locking magnet, the cut-off for transferring the battery circuit from the main magnet to the locking magnet and secondary signal, the arrangement of the primary and secondary signals with reference to each other, and some other minor points.

This application was completed about the 20th of December, and immediately upon its completion I took it to Washington myself and filed it on the 21st of December, 1872. It was issued on the 31st of March, 1874, as No. 149,152, and is Exhibit N. I remained in Washington at this time nearly a week attending to various matters relating to the patents of myself and Mr. Hendrickson.

On the 6th of January, 1873, I left home for Pittsburg for the purpose of showing the new signal machine which Mr. Unger had made to Mr. Pitcairn, the superintendent of the Western Division of the Pennsylvania railroad. After examining the machine he said he would like to have it set up near his office at the outer depot, Pittsburg, so that he might observe its operation. I made ar-
87 rangements to have this done, and then left Pittsburg and proceeded *via* Cincinnati to St. Louis, Mo., where I arrived on the 15th of January, 1873, which I believe was Sunday. The following week I exhibited one of our signals (which had been sent on by express) to a convention of Western railroad men then in session at the Southern Hotel, which was my object in visiting St. Louis at this time.

After the adjournment of the convention I proceeded to Kansas City, Mo., thence to St. Joseph, Mo., thence to Council Bluffs, Iowa, in search of a witness whose testimony we expected would be required in a probable interference case in the Patent Office between one of my patents and an application or a patent of one Wm. Robinson. I found the witness I was in search of at Council Bluffs on the 22d of January.

Before leaving St. Louis I received a letter from my partner, Mr. Ashley, requesting me to go at once to Baltimore, Md., and confer with Mr. A. G. Davis, who was then superintendent of telegraphs on the Baltimore and Ohio railroad, with reference to the placing of some signals upon that road. I left Council Bluffs on the night of January 22, intending to proceed by the way of Burlington, Peoria, Indianapolis, and Cincinnati to Baltimore. Before reaching Cincinnati the train ran off the track in the middle of the night, and

both passenger cars were wrecked. The weather being intensely cold, the exposure consequent upon this accident brought on an illness, for which reason I stopped off at Hamden, O., and proceeded to Gallipolis, O., a town lying off the direct line of the road, where I had friends with whom I intended to have stopped until sufficiently recovered to resume my journey.

While here I telegraphed to Mr. Ashley acknowledging the receipt of his letters, and stating that I hoped to be in Baltimore the following Monday. I did reach Baltimore on the 30th of January, 1873, but was not well enough to see Mr. Davis, and so came directly home to Elizabeth. As soon as I was well enough, which was within a very few days, and prior to the 10th of February, I went to Baltimore and had a conversation with Mr. Davis in relation to
88 the introduction of our signal system on the Baltimore and Ohio railroad. Speaking of the system we had in use near Pittsburg, he expressed the opinion that it would not answer for the Baltimore and Ohio railroad for the reason that the signals would be required at distances from one to two miles apart, which involved the erection of a battery-house at each signal, provided with a stove to keep the battery from freezing in the winter and a man to attend it, as the regular stations on the Baltimore and Ohio railroad in the mountain regions were sometimes eight or ten miles apart. I informed him that I had already devised a plan by which the requisite number of signals on eight or ten miles of road could be worked from one battery, which could be placed in the existing station-house, and that I was willing to undertake to do this at any time. With this understanding we afterwards put up a signal on this road in Baltimore in order to illustrate its practical operation. On the 10th of February, 1873, I went again to Sunbury and Northumberland, Penn., in consequence of information received that the signals at that point were not working with entire reliability. I remained at Sunbury and Northumberland until the early part of March. The difficulty with the signals was of a very obscure character and different from anything I had ever met, and was only detected after a long course of experiment. Owing to some peculiarity in the geological formation of the earth at that point there were times when it was impossible to complete the electric circuit by means of the earth with sufficient certainty to operate the signals. This was especially the case in the winter or in cold weather.

The intermittent character of the phenomenon made it very difficult of investigation, and as I had never met with or heard of anything of the kind before, I wished to investigate it very carefully. I came home to Elizabeth, by way of Hazleton and Easton, in the early part of March. I then went to Boston for some days, mainly on business of a personal nature. About the 1st of April, 1873, or within three or four days thereafter, Mr. Edwin D. McCracken,
89 a gentleman with whom I had previously some slight acquaintance, called at our office in New York city and represented that he had had something to do with the maintenance or working of the system of signals which had been put up by Mr. Hall on the Harlem railroad in New York city. Mr. McCracken

professed to be some sort of an electrician, and the impression that I gathered from his remarks was that he had been employed by the railroad company to take care of the signals and keep them working.

He stated that they had had a good deal of difficulty in keeping the signals in proper working order, and that if I would undertake to do it for him, that he thought I would be well compensated for it. I asked him what the nature of the difficulty was, and he informed me that it arose principally from the number of separate and detached batteries that were employed, and which it was almost impossible to keep in good working condition; but that the signal machinery itself worked satisfactorily. I explained to Mr. McCracken the general character of my invention for working a number of signals from one battery, and considerable conversation occurred between him and Mr. Ashley and myself.

He came in to see us about it several times within the next few days, and the ultimate result of the interviews was that we authorized him to make a proposal to the railroad company to fit up the existing system of signals so that they could be worked in accordance with my plan.

He asked me to give him a written memorandum stating what could be accomplished by this plan, to be used by him in the course of these proposed negotiations with the railroad company. I prepared such a memorandum, accompanying it with a diagram showing the proposed arrangement, with as much detail as I then thought prudent to make known in advance of an application for a patent.

I took a press copy of this memorandum (which includes a diagram) in Mr. Ashley's letter-book, and then gave it to Mr. McCracken. He expressed himself as very positive that with the aid of the information contained in the memorandum he could effect the proposed negotiations. The press copy of this memorandum appears
90 on page 299 of Mr. Ashley's letter-book, and bears no date. The memorandum was made either on the 10th or 11th of April, 1873. I am certain of this fact, because the letter preceding it in the book bears date April 10, 1873, and the next letter following bears date April 11, and I am certain that I copied the memorandum in the book in regular order according to our invariable custom on the first blank leaf at the end of the existing copies. I never heard that Mr. McCracken's proposed negotiations amounted to anything. I have no recollection that he ever called at the office again while I was present, although he might have done so, as I was away a great part of the time. I now cut out the leaf from the letter-book of Mr. Ashley containing the press copy of this memorandum and diagram and place it in evidence. (Letter-book leaf referred to put in evidence and marked Exhibit C C.)

Perhaps two weeks after this interview with McCracken, in anticipation of his making his proposed arrangement with the Harlem Railroad Company, I applied to Mr. Moses G. Farmer, who was then electrician of the American Compound Wire Company, of New York, and requested him to give me an estimate for a compound wire of steel and copper of the size of an ordinary telegraph wire,

but having about three times the usual conductivity, which I proposed to use for the two battery conductors in case we got an order to put my improved system on the Harlem road. Soon after I met Mr. McCracken in the street, and inquired how the negotiations were proceeding, but could get no definite information from him, and, after waiting a few days longer, I concluded it would be prudent, in view of the circumstances, to prepare to file my application for a patent. As the various parts of the combination, circuit-closers, signals, signal machinery, etc., had already been thoroughly tested in practice, and almost continually for over a year, it did not seem to me necessary to test the new combination in actual service before making an application for a patent, as it was a very easy matter for any competent electrician to calculate from existing data the
91 amount of battery power, the size of conductors, and the proportionate electrical resistance of the different parts, so as to insure the satisfactory operation of the system in practice. After completing and filing an application for a patent on an improved track connection which had been invented by Mr. Hendrickson, and which was sent to Washington and filed on the 25th day of April, 1873, I prepared the application for the patent, which was issued July 1, 1873, as No. 140,536, and is "Exhibit A."

This application was filed as soon as the model was completed, and reached the Patent Office on the 15th of May, 1873.

Much of my time during the remainder of the month of May was occupied in preparing an application for a reissue of my patent, No. 129,425, the application for which was completed and filed May 28, 1873, and which was granted October, 21, 1873, as No. 5622.

I next went to work on an application for a patent for a combination of circuits, designed for the working of automatic signals on sections of single track where the trains run in both directions, which application was completed and filed in the Patent Office on the 11th of June, 1873. I then devoted myself for some time to experimenting with and testing an arrangement for operating automatic signals which had been put up, according to my directions, by Mr. Hendrickson, near Bear creek, on the Lehigh Valley railroad, between Mauch Chunk and Penn Haven.

This application, which was made at the request of Mr. H. S. Goodwin, one of the officers of the Lehigh Valley Railroad Company, differed very materially from anything we had before attempted. The continuous insulated section of track was about five thousand feet in length. The signal was placed at the entrance of the insulated section, and was so arranged as to indicate "danger" when in its normal position, which indication was changed to "safety" by the action of the battery as the engine approached the signal. As soon as the engine had passed the signal, the connection made across the insulated rails from one side of the track to the other by the wheels and axles of the train cut the battery
92 current off from the signal magnet, allowing it to fall back to its normal position indicating danger, and the battery remained thus cut off from the signal as long as any portion of the train remained upon any part of the five thousand feet of insulated track.

Consequently, if any train following the first one approached the signal, the latter could not be moved into a position indicating safety or track clear, because the battery was cut off by the preceding train, or some part thereof.

The object of this arrangement was to meet the peculiar conditions of traffic existing on the Lehigh Valley railroad, which is an exceedingly crooked road, but for the most part very nearly level, and having no grades opposed to the direction of the heavy traffic. Under these conditions trains are frequently run over the road having more than two hundred cars drawn by a single engine, and they run in this way for miles when a greater part of the train is not visible from the engine. It therefore sometimes happens that a part of the train becomes detached and is left behind, and this arrangement of signals, which I have described, was designed to provide for this emergency. In the previously existing systems, if a portion of a train became detached in this way, upon the arrival of the locomotive at the end of the section, it would cause the danger signal in the rear to be reversed, giving an indication of safety, when in fact the track was obstructed by the detached portion of the preceding train. I experimented some weeks with this system at Bear creek, and at length got it so that the insulated section of five thousand feet in length performed its functions as a continuous circuit-closer perfectly and under all conditions of weather, so much so that the officers of the Lehigh Valley Company, after a long and thorough test, stated that they were fully satisfied with the reliability of the entire system there shown. The month of August, 1873, I spent as a vacation. The 1st of September I went to Cincinnati, Ohio, and exhibited our signals at the Industrial Exposition, after which I was employed for some time putting up and testing some signals which had been ordered by the Pennsylvania Company, at Southwest Junction, near Greensburg, Pennsylvania. As winter came on my
93 health failed considerably, in consequence of exposure while engaged in outdoor work during inclement weather. During a visit to Northumberland, in the latter part of the winter, on business connected with the signals there, I contracted a severe cold, which led to an illness, which incapacitated me from doing any outdoor work, or much work of any kind, until the following spring, a year afterwards, being the spring of 1875, so that I have little or no personal knowledge of any of the practical work which was done during that period.

Early in the year 1875, a proposition was made to me jointly by the officers of the Western Union and the Gold & Stock Telegraph companies to take charge of their patent business, with liberty to devote such attention as was necessary to the signal business in which I had previously been engaged. As soon as the state of my health permitted, which was in March, 1875, I accepted this offer, and have since devoted a great part of my time to this work. I will here state all the applications for patents for my own inventions, and for those of Mr. Hendrickson, which I have mentioned in this answer, were prepared by myself personally. I also made the accompanying drawings myself, and attended to the prosecution of the

cases before the Patent Office, although they were sometimes revised, especially the more important ones, by my solicitor, Mr. Livingston, before being filed.

(Defendants' counsel objects to the statement in the answer, page 114 of the manuscript testimony, being page 69 of the printed testimony, in regard to the interview or interviews with Mr. McCracken, in which the witness gives certain representations of statements made by Mr. McCracken; also to that part of the answer on page 121 of the manuscript and page 72 of the printed evidence, in which the witness mentions a statement as made by the officers of the Lehigh Valley Railroad Co.)

Int. 2. Do you know the present residence of Edwin D. McCracken, of whom you speak in your testimony?

94 Ans. I do not. I have made inquiries of every one whom I thought would be likely to know, in order to ascertain his whereabouts, for the purpose of procuring his testimony in confirmation of the facts I have stated as to his conversations with me in April, 1873. I last heard of him at Chicago, Ill., and at the same time learned that he had a domestic difficulty with Mrs. McCracken, and went away from home without leaving his address. Since that alleged event I have been unable to find any trace of him.

Int. 3. Have you ever seen him, except upon the two occasions which you have stated?

Ans. I have no recollection of ever having seen him since meeting him in the street in April or May, 1873. I had met him casually perhaps two or three times before he came to my office to talk over the signal matter.

Int. 4. You speak of Mr. A. G. Davis as connected with the Baltimore and Ohio Railroad Co. Does he still retain that connection; and, if not, how long did he, and where is he now?

Ans. Mr. Davis' official connection with the Baltimore and Ohio railroad terminated not long after the conversation mentioned in my previous answer—it may have been a year, more or less. I have at present no means of fixing the date when he retired from that position. He has since that time, and is now, engaged in business on his own account in the city of Baltimore, where he now resides.

Int. 5. Please read that portion of the testimony in chief of Thomas S. Hall, found on page 110 of the defendants' evidence, fol. 422 and 423, in which, among other things, he says he asked Stephen C. Hendrickson if it was true that he had taken his (Hall's) double-circuit instrument and other devices of his invention to Mr. Frank L. Pope's office in Broadway, New York city, and if they were engaged in getting up devices that would be an infringement upon the same. Mr. Hall locates this as to place and date at Stamford, in 1869, while said Hendrickson was at work for him. Have you read the evidence to which I refer?

Ans. I have.

Int. 6. State whether or not Hendrickson, with your

95 knowledge, ever took to your office in Broadway, or to you in any other place, Mr. Hall's double-circuit instrument, or any

model, device, diagram, or representation of it, or any other devices, of Mr. Hall's invention while Hendrickson was to work for Hall in 1869, or at any time in the year 1869, or afterwards.

Ans. I have no recollection of any such occurrence, and am very positive that nothing of the kind could have happened without my remembering it.

(Defendants' counsel object to the latter part of this answer, as incompetent.)

Int. 7. When did you first converse with said Hendrickson in reference to matters connected with the electric railway signal business?

Ans. About the first of May, 1871.

Int. 8. Had you, prior to this time, been acquainted with him?

Ans. I had known him very slightly as a casual acquaintance; I was never at all intimately acquainted with him until after the interview in Mr. Lewis' office, of which I have already spoken, and which took place at the time mentioned in my last answer.

Adjourned to Feb. 14, 1879, 10 a. m.

HARTFORD, *February* 14, 1879.

Met pursuant to adjournment.

Parties represented as before.

Deposition of S. C. Hendrickson.—Continued.

Cross-examination of Mr. HENDRICKSON resumed:

Cross-int. 109. In your answer to cross-interrogatory 87 you
96 stated you could not tell the day when you went to meet Mr. Hall at Flushing without looking to some of your memoranda. Have you looked at you memoranda, and can you now state?

Ans. I have looked for my memoranda, but fail to find it with me; but can state that it was during the time I was constructing a line of telegraph from Flushing to College Point for the Flushing & North Shore Railroad Co.; after the completion of the signals for the company I was there daily from August 17, 1869, until September 20, and saw the signals working whenever they were operated by the bridge-tender.

Cross-int. 110. Did you do any work at Hoboken under Mr. Hall's directions during the early part of your employment by him?

Ans. I did.

Cross-int. 111. What was it?

Ans. Repairing cables, changing switch connections, putting up one new signal on the Morris & Essex railroad, and also took care of the batteries a part of the time.

Cross-int. 112. Do you recollect the year in which you began this work at Hoboken?

Ans. February, 1869.

Cross-int. 113. Have you any memoranda with you by which you fix that date?

Ans. I have.

Cross-int. 114. Please produce it.

Ans. Here it is. (Witness produces a diary in which is an entry of Monday, Feb. 1.) "Went with Mr. Hall to Hoboken and Newark. He explained about what I was to do." This book also contains, under date of Monday, January 11, the following entry: "At 145 Broadway, Mr. T. S. Hall called to see me in relation to his signal business."

Cross-int. 114½. In your answer to interrogatory 50, you commenced by saying that your next work after that, on the Boston & Lowell road, was at Bethlehem, and then you corrected yourself by saying that you were mistaken, and that the next work was on the Pennsylvania railroad. Did you, before making this correction, look at a memorandum which was before you to refresh your memory?

97 Ans. I was undecided, and looked at a memorandum to see whether I was right or wrong in the matter, and I found that I was mistaken.

Cross-int. 115. Did you have the same memorandum before you all the time while you were giving your testimony on the direct examination in order to guide your memory?

Ans. I occasionally referred to the memoranda in order to get the proper dates.

Cross-int. 116. When was this paper made to which you thus referred?

Ans. Within a month from the present time; it was taken from diaries.

Cross-int. 117. Was the memorandum made for the purposes of this examination?

Ans. It was.

Cross-int. 118. Why did you preserve Exhibit X?

Ans. Well, I have not preserved that any more than I have other sketches which I have made from time to time; I have been accustomed to saving letters and memorandas for several years.

Cross-int. 119. Where did you keep Exhibit X?

Ans. It was among all my sketches.

Cross-int. 120. Did you keep it for use as a working plan?

Ans. I could say yes.

Cross-int. 121. Did you ever use it as a working plan?

Ans. Not particularly that one.

Cross-int. 122. When did you first look at it again after you had made it, and showed it to Mr. Pope?

Ans. After I had made the model, Exhibit A A.

Cross-int. 123. What did you look at it for then?

Ans. Merely to understand the matter, or to see that I understood the matter more thoroughly.

Cross-int. 124. When was this?

Ans. It was in December, 1872.

Cross-int. 125. Where did you find Exhibit X at that time?

Ans. In amongst my sketches.

Cross-int. 126. When did you next look at this Exhibit X?

98 Ans. Some time during May, or about the time Pope filed his patent.

Cross-int. 127. In your answer to int. 56 you say that at the time you made Exhibit X you showed it to Mr. Pope to know whether it was as he intended it. What did he say as to this when you showed it to him?

Ans. He said it was correct, or words to that effect.

Cross-int. 128. Have you any recollection except as your memory is guided by the pencil memorandum of "December 3, 1872," on Exhibit Z of the date when said Exhibit Z was made?

Ans. I recollect of making it in the rear part of 198 Fulton street, New York city, and taking it out to Mr. Pope and showing it to him, which he looked at and put the letters "S. C. H., December 3, 1872," on that day.

Cross-int. 129. When did you first discover that your use of machinery in aid of electricity in Exhibit AA was not new?

Ans. Soon after my patent was issued. I understood the combination of my patent was all right, but the two elements alone were not new.

Cross-int. 130. How were the sections of track insulated at Bethlehem?

Ans. By the introduction of rubber packing between the fish-joints and rails and through the bolt holes for connecting fish-joints to rails, and also between the two rails.

Cross-int. 131. Was the same mode employed at Bear creek?

Ans. It amounted to the same. The rails were driven back so as to make a space of about 1½ inches between the rails. An L-shaped piece of iron was placed under and against the end of each rail; a piece of hard wood or leather was put in the open space between the rails; then, in order to make the joint safe for traffic, a piece of oak wood about 5 feet in length, shaped out on one edge to fit the shape of the rails, was bolted to the rail and then spiked to the tie.

Cross-int. 132. Which plan worked the best?

Ans. There was no difference in the working; the latter was more substantial.

99 Cross-int. 133. Did not the India rubber insulation soon fail of effect after ordinary use?

Ans. It did not in this instance.

Cross-int. 134. What was the difficulty with it in practical operation?

Ans. Rubber put on the outside would naturally rot sooner than wood or leather, and the reason of introducing the latter description of insulated joints was that it could be done cheaper, and by any of the section foremen.

Cross-int. 135. Which mode did you adopt at tunnel No. 3?

Ans. The same as in the latter description.

Cross-int. 136. Which mode did you adopt at the Centennial grounds?

Ans. The same as at tunnel No. 3.

Cross-int. 137. Did you ever apply the rubber method after its application at Bethlehem?

Ans. I don't think I ever did.

Cross-int. 138. In regard to the submergence of the insulated sections of the track at Bear creek, as to which you testified in your answer to int. 84, how high did the water come as respects the rails?

Ans. It was over the rails in some places. I did not measure it.

Cross-int. 139. What was the length of this insulated section?

Ans. It was nearly a mile. It was over 5,000 feet.

Cross-int. 140. How many lengths of rail in this section were completely under water?

Ans. Well, I could not state the number, but the distance, I should judge, was from three to four hundred feet.

Cross-int. 141. How many trains did you see pass during this period of submergence over the submerged tracks?

Ans. I cannot state the number of trains. It was along in the afternoon, and the coal trains were the principal traffic on that road at that time.

Cross-int. 142. How long did this submergence continue as you have described it?

Ans. Well, it was off and on for two or three hours. It
100 was during a heavy thunder-storm, and the water from the mountains ran down and over the track for some time after the showers were over.

Cross-int. 143. Do I understand you that the submergence was varying every few minutes so as to be more or less complete according to the varying of the storm or of the freshet?

Ans. You are correct.

Cross-int. 144. Where were you during the storm?

Ans. I was out in it part of the time, and at the signal occasionally.

Cross-int. 145. Were you not mostly in doors during the storm?

Ans. I was under a shelter part of the time; I had an umbrella with me.

Cross-int. 146. Did not the danger of wash-outs prevent the trains from running as usual during the storm and immediately afterwards?

Ans. I did not hear of any on that road; I saw nothing of that kind; the trains run as regular as at any other time when I had been there.

Cross-int. 147. How many signals did you see operated by a passing train while the tracks were submerged?

Ans. One at Bear creek.

Cross-int. 148. Did you see it operated more than once during any time when four or five hundred feet of the track was submerged?

Ans. I did.

Cross-int. 149. When was this?

Ans. It was some time in July.

Cross-int. 150. How long was the insulated section of tunnel No. 3, which you saw submerged?

Ans. The length of the tunnel proper is 3,800 feet, the cuts at each end are about 500 feet each, the insulated section was about a mile.

Cross-int. 151. How much of that section was completely under water?

Ans. It was at the upper cut where the water had come
101 down, and would not run off through the tunnel. That lasted during one night, and washed the underpinning of the track through the tunnel and cut.

Cross-int. 152. How many trains did you see pass over the submerged part of this cut before the washout?

Ans. There was only one; trains do not run frequent on that section, there being only four trains a day each way.

Cross-int. 153. How much of the cut was submerged when that train passed?

Ans. Well, there was perhaps fifty feet of it; the water had just begun to back up.

Cross-int. 154. At what hour did the train pass?

Ans. Between 6 and 7 o'clock p. m.

Cross-int. 155. What day was this?

Ans. It was during the latter part of August, the year 1875; it was the time I was up at the tunnel.

Cross-int. 156. How far was the submerged part of the section from the mouth of the tunnel?

Ans. About fifty feet from the mouth of the tunnel.

Cross-int. 157. Where were you when the train passed?

Ans. I was at the end of the tunnel, with the door-tender, at the submerged end.

Cross-int. 158. Were the rails completely covered by water when the train passed?

Ans. You could just see the outlines—the tops of the rails—through the water.

Cross-int. 159. How long a space did you see submerged on the Centennial grounds?

Ans. I did not measure the distance—about 900 feet.

Cross-int. 160. How long was the insulated section of which that was a part?

Ans. That was about 2,000 feet.

Cross-int. 161. Were the rails entirely under water for about 900 feet?

Ans. They were.

Cross-int. 162. How many trains did you see pass during this submergence?

Ans. A great many; I could not count the number; the water stood on the track during the greater part of the day.

102 Cross-int. 163. How many of these trains do you now recollect having observed to operate your signals?

Ans. I was watching, soon after the track became submerged, for about three hours. During that time the trains were running under five minutes headway. I went, after remaining there the time stated, to our exhibit in the main building, and remaining there for a short time. I returned again to the crossing opposite Machinery Hall, and found the track still submerged. I waited until 5.30, when I disconnected the alarm bells for the night, as it was necessary to

have all the alarm bells disconnected, the company using that portion of the track after six o'clock for storage cars, and they being left upon that section of insulated track would cause the alarm bell to ring unnecessarily. The signals were kept connected all the time. I cannot say the precise number of trains.

Cross-int. 164. What were you watching the trains for during that three hours?

Ans. I was there for the purpose of explaining the mode of operation of the signals, and it was my custom to attend daily.

Cross-int. 165. Were you there watching to see if the trains operated the signals properly?

Ans. I was partially there for that purpose.

Cross-int. 166. Did your applications of your railway signals at any of the points referred to on your direct examination ever fail to work on account of an inability to create or call into operation the necessary electric circuits?

Ans. Not in relation to the insulated or track circuits.

Cross-int. 167. Did they in reference to any circuits?

Ans. They did in the battery wires becoming broken, and also in the Kerite or insulated wire becoming broken.

Int. 168. Did they fail to work for any other reason, in any other place or at any other time?

Ans. By the section men taking out a rail on the insulated sections. That is about the only cause that I recollect.

Int. 169. How many times were you at Sunbury during the time when your apparatus was in operation there?

103 Ans. On three different occasions.

Int. 170. Please mention them?

Ans. The first was October 29 to November 5 or 6, 1872; the second was August, 1873; the last time was between January and February, 1874.

Int. 171. How long did you stop there the last time?

Ans. About a day or two.

Cross-int. 172. Had you any acquaintance with devices for electric railway signals, and their construction and operation, prior to your first employment by Mr. Hall?

Ans. I do not recollect as I ever had.

Cross-int. 173. What was the last work which you did for Mr. Hall or his company before you left their employment?

Ans. The regulating of the wires and track circuit-closers and batteries at or near Stamford, Conn., on the N. Y. and N. H. R. R., and some on the New Canaan road, which I suppose is the same thing.

Re-examined by Mr. CHAMBERLIN:

Redirect 174. I notice in the Exhibits X and Y, and I presume they are in other exhibits, an appearance in several places of a line, representing a line of wire apparently, which appears upon the exhibits to be cut off on each side of the wire which they would otherwise cross. Does that represent actual breaks in the line of wire, or what does it indicate?

Ans. It indicates that it is a continued wire running under the main wire. In making the sketch it was not convenient to get rid ink or red pencil to draw those lines, consequently I left them broken. The commencement of a branch from the main circuit, you will perceive, is attached directly to the main line.

Redirect 175. State whether or not that is a common way of representing independent wires crossing each other in electrical diagrams, according to your observation.

(Counsel for defendant object to the question, as leading, and also as calling for the opinion of the witness.)

Ans. It is, where but one color is used.

104 Redirect 176. In your answer to int. 163 you say in answer to the question, "How many of these trains do you now recollect having observed to operate your signals?" the trains were running under five minutes headway. What do you mean by that?

Ans. I mean that the trains were running five minutes apart.

Redirect 177. In answer to cross-int. 117, in reply to the inquiry, "Was the memorandum made for the purpose of this examination," you answer, "It was." What do you mean by the word "made"?

Ans. It was taken from different diaries and memoranda and letters of different dates, which I had in my possession for convenience sake.

Redirect 178. When, with reference to the actual date of the several transactions to which the memoranda relate, were the original entries from which you prepared this memorandum made?

Ans. They were made at the time of the transaction.

Redirect 179. In reply to cross-int. 118, "Why did you preserve Exhibit X?" you answer, "Well, I have not preserved that any more than I have the other sketches which I have made from time to time. I have been accustomed to saving letters and memoranda for several years." Please state whether by this you mean that you have a general habit of preserving all business letters, memoranda, and sketches, or only that you did it occasionally.

Ans. I had a general habit of doing so.

Redirect 180. How many similar rough sketches like this Exhibit X have you now on hand, as the savings of the time, say, since you was first employed by Mr. Hall, as nearly as you can estimate?

Ans. I could not state the number; they are all in one package, for different purposes. I have a few here.

Redirect 181. State the measurement, as nearly as you can give it, of a package that would contain them all.

Ans. I suppose the roll of them, rolled up, would be eight inches in diameter; that is as near as I could get it.

105 Recross-examination by Mr. BALDWIN:

Recross-int. 182. Can you state the time when each of the plans in that eight-inch bundle was made?

Ans. I could, by referring to the bundle, as some of the sketches have the dates attached to them.

Recross-int. 183. Do you generally put the date on your sketches?

Ans. Anything which I think is new or important.

Recross-int. 183. Do you put the date on when you make them?

Ans. I do.

Recross-int. 184. Why did you not date Exhibit X?

Ans. Because I think that the time in my diary was sufficient to enable me to find the date. It was not my own invention was the reason.

Recross-int. 184. What time in your diary to you refer to?

Ans. Between October and November, 1872.

Recros-int. 185. What entry in your diary for October or November refers to Exhibit X?

Ans. During the time that I was at Sunbury and Bethlehem, and also referring to Exhibit Y. I know positively that it could not have been after that.

Recross-int. 186. Do you mean that you did not date Exhibit X when you made it because you were expecting to make another sketch of the same thing in your pocket diary or memorandum book?

Ans. I mean the reason I did not date it was because it was Mr. Pope's invention, and he would take care of all the details in the matter.

Recross-int. 187. Why did you not date Exhibit Y?

Ans. Well, there is November 6, the last date, and it was made on that date—on or before that date.

Recross-int. 188. Does not a date of January 25 come next immediately above the upper part of Exhibit Y on the right-hand page of your pocket book?

Ans. It does. January 25 is at the bottom of a column of dates as follows, viz:

106	1872.	
	Oct. 21. Cash from J. N. Ashley	$25 00
Dec. 30.		10 00
" 30.		5 00
Jan. 12.		40 00
" 25.		10 00
Ferriage		6
1 car fare to Flushing		40
1 car fare to Flushing		40
1 car fare		70
		$1 56

An ink-line is drawn across the first line, being the item of October 21.

Recross-int. 189. Does the next page of your diary, being the other side of the leaf on which the foregoing entries were made, commence with the heading and date of 1873, January 13, and continue down the page with sundry entries for the 14th, 15th, 16th, and so on of January?

Ans. It does.

Recross-int. 190. Why did you not date Exhibit Z?

Ans. Because Mr. Pope had already done so.

Recross-int. 191. How came he to date your diagram in this way?

Ans. I don't recollect why he did it. I frequently certify my signature S. C. H., which I thought sufficient at the time.

Recross-int. 192. Did you put the initials S. C. H. on Exhibit Z opposite the date?

Ans. I have stated before that Mr. Pope done it.

Recross-int. 193. Do I understand you to say that in making Exhibits X and Y you used broken lines as a means of indicating a continuous line passing under another line?

Ans. I do.

Recross-int. 194. And do you also say that it is the common custom of draughtsmen in sketching electrical apparatus to do this where they do not color their lines?

Ans. All those draughtsmen that I ever see make electrical
107 sketches do it in that manner, or else you could not trace the circuits without a different color.

Recross-int. 195. Is it the custom to do this whenever the sketch shows wires crossing each other?

Ans. It is in electrical sketches.

Recross-int. 196. Is this Mr. Pope's custom in making sketches of electrical apparatus?

Ans. I believe it is when he does not use two colors.

Recross-int. 197. Please look at Exhibit A, and state whether Mr. Pope has made his sketch in that way in the plan accompanying these specifications.

Ans. He has not; but each wire is numbered and each magnet lettered; also the battery and main battery wires, which is an equivalent to the description I gave of drawing electrical sketches.

Recross-int. 198. Has Mr. Pope followed this custom in the sketches accompanying the specifications of his patent 103,077 of May 17, 1870?

Ans. He has not, but the wires are numbered and magnets lettered.

Recross-int. 199. In the Lake patent, Exhibit P, has this custom been followed?

Ans. It has not; for the same reason stated above.

Recross-int. 200. Were any of the sketches to which you have just referred, connected with these patents above mentioned, drawn with colored lines?

Ans. I see no colored lines, but the wires are numbered and the magnets and batteries are lettered, as stated before.

Redirect by Mr. CHAMBERLIN:

Redirect 201. Turning to the pages of the memorandum-book on which is Exhibit Y, state what is the last date upon the left-hand page, above and close to the beginning of said sketch on said book.

Ans. November 6, 1872.

Redirect 202. About what is the space between the footing of the

figures on that page and the upper line of the beginning of said sketch?

Ans. About three-eighths of an inch.

108 Redirect 203. Examine the book and state whether there appears to be any reason why the later dates on the right-hand page should not have followed those at the left and been at the foot of that page, except as that space is occupied by a portion of Ex. Y?

(Defendants' counsel object to the question, as leading and calling for a matter of opinion.)

Ans. The reason is that it was money that I had received from Mr. J. N. Ashley for expenses, etc., for which I gave him credit.

S. C. HENDRICKSON.

Subscribed and sworn to before me, this 15th day of February, 1879.

E. E. MARVIN, *Examiner.*

Deposition of Frank L. Pope.—Continued.

Testimony of F. L. POPE resumed.

Examined by Mr. CHAMBERLIN:

Witness presents a diagram of the application of the Pennsylvania railroad, put up in August, 1872, and showing the arrangements of the circuits at Roups and Shady Side, described on page 96 of the manuscript testimony and pages 59, 60 of the printed testimony, and which is placed in evidence and marked Exhibit D D.

Int. 9. The answer of the defendant in this case alleges that the invention described in your patent, Ex. A, was in fact invented and discovered by Thomas Shepard Hall, who then resided at Stamford, Conn., and who, at the time the patent was obtained by you, was perfecting his invention, and that you at that time obtained

109 knowledge of the invention of said Hall, and appropriated the same or a part thereof in your said application for said patent. Had you at that time any knowledge, intimation, or suspicion that said Hall had in mind or thought the invention of a series of automatic block signals to be worked by one battery?

Ans. None whatever.

Int. 10. When did you first acquire or receive such knowledge or intimation?

Ans. The first intimation I received that Mr. Hall had a similar arrangement was in the winter of 1873–'4—I think in December, 1873—some one told me, I do not recollect who, that he had on exhibition at the Lowell depot, in Boston, a system consisting of a series of automatic block signals operated by a single battery. Not long after that—perhaps two or three months—I saw a notice in one of the New York papers that Mr. Hall was giving an exhibition of his apparatus in the city, I think at the Erie railroad depot, and I sent one of my employees to look at it. He saw it and inspected it,

and reported to me that the signals were arranged in that way. The first time that I ever myself saw Mr. Hall's arrangement was on the Boston and Albany railroad, at South Framingham, Mass. This was in the winter of 1875–'6.

Adjourned to February 18, 1879, 10 a. m.

Deposition of F. L. Pope.—Continued.

HARTFORD, *February* 18, 1879.

Met pursuant to adjournment.

Parties represented as heretofore.

Examination of F. L. POPE, witness for complainants, by Mr. CHAMBERLIN, resumed:

Witness states: I notice two of my answers that should be
110 corrected: first, the answer to int. 10, my testimony, in which the time stated as "perhaps two or three months," should be so changed as to read, *perhaps a year;* and on page 89, manuscript evidence, page 57 of printed testimony, the statement, "It does not, however, contain any of the elements of the combination set forth in my patent," should be changed by striking out "set forth," and inserting in place thereof the word *claimed*, and by adding as follows: "Although, as this signal machine is provided with a device for retaining the disc in its displayed position after the actuating current has been interrupted, and which is so arranged as to release the signal by the action of another current, it might be used successfully in that combination."

Int. 11. What do you mean by the statement in manuscript testimony, page 67, page 47 of printed copy, "that you find that a railroad track would admit of four hundred times the possibility of leakage of current per mile (which always exists in a greater or less degree, in consequence of imperfect insulation) with only the same diminution of the working force of the current?" Please explain and illustrate your meaning so that it may be understood by one not familiar with the action of electricity.

Ans. I will try to make my meaning more clear. In order to produce a given mechanical effect at a distance it is necessary to transmit a given quantity of electricity to that point. This may be done by the use of a conductor having a small or having a large sectional area. When the smaller conductor is used, the battery must be so arranged as to furnish electricity of considerable tension. Tension is a state analagous to pressure, in that it causes a greater quantity of electricity to pass through a wire in a given time when the tension is high than when it is low. When the conductor is large, it permits the same quantity of electricity to pass through it, having a low tension, as would pass under the first-named conditions, with a much higher tension. Now the leakage at any given point where the insulation is imperfect is proportionate to the tension under which the electricity is traversing the wire, and, therefore, is much greater, other things being equal, in

the first case than in the second, while, if there were no
111 leakage at all, the quantity of electricity arriving at the distant point would be precisely the same in both cases.

The action of electricity, under the conditions I have stated, is analagous to that of flowing water, and may be very well illustrated as follows: Suppose a given mechanical effect is required to be produced by means of a common overshot water-wheel, and a flow of one thousand gallons per minute is required to actuate this wheel. Now this amount of water may be conveyed to the wheel through a comparatively small closed pipe, under a heavy head or pressure from the reservoir, or in a very wide and shallow open trough, under a very small pressure, or no pressure at all. The performance of the water-wheel would be the same in either case. It is obvious, however, that if a leak of equal area were made in both the water conductors that such a leak would cause a loss of a much greater proportion of the water in the smaller conductor than in the larger one, and this would be solely owing to the greater pressure in the smaller conductor, which is precisely analagous to the tension of the electrical current in the other case.

Int. 12. Have you read and do you understand the testimony of Mr. Morton in this case?

Ans. I have read it, and I believe I understand the essential points of it.

Int. 13. Please turn to his answer to int. 8, examine it again, and state as an expert whether or not one sufficiently familiar with the state of the art to be reasonably fit to take charge of the erection of practical constructions involving the application or employment of electricity could have used and employed the combination described as your invention with the aid of your specification, and if you do not agree with the witness, Morton, in your answer, give the reasons why you disagree?

Ans. In my opinion, a person properly skilled in the art could construct and apply to use, without further experiment or invention, a successful signalling apparatus for railroads, provided he were familiar with the state of the art at the date of complainants'
patent, No. 140,536. This patent is entitled "An improve-
112 ment in circuits for electric railroad signals." It does not purport to describe all the details of those parts of the apparatus already well known, but is simply intended to describe an improved system of electrical circuits for more conveniently and economically connecting and operating devices and machines already known, in order to produce a practical result which was also known.

Prof. Morton says that the problem of insulating the portions of the track connected with the wires from the earth "would be one of excessive difficulty, if not, indeed, incapable of any successful solution in practice." In reply to this I say that a practical experience of more than a year, at the date of the patent, and almost continuously from that time to the present, has amply demonstrated that no special insulation of the track from the ties is necessary in order to work signalling apparatus successfully. The conditions in this

case are very different from those of the ordinary telegraph lines to which Prof. Morton refers, in support of his opinion.

A signal circuit is usually not more than from five to ten miles in length; a telegraph circuit is usually fifty times as long. In order to force the necessary electricity through this great length of wire, these lines are worked under a very high tension compared with that necessary for a short line for signalling purposes.

For this reason, as explained in my answer to int. 11, the loss of current from defective insulation is comparatively small. Again, the actual quantity of electricity passing through the circuit is, perhaps, fifty times as great in a signal circuit as it is in a telegraph line; consequently, a leak that would carry off nearly all the current from a telegraph wire would only diminish the current of a signal wire by a small percentage. Furthermore, the specification states that the invention is not confined to the use of the particular devices therein described, for closing the electric circuit at points from which a signal is to be operated. In his answer to cross-int. 45, Prof. Morton says that other devices for closing a circuit by the action of a moving train, which did not depend on the insulation of the track or any portion thereof, were known, patented, and
113 described in printed publications prior to the date of complainants' patent. The specification describes a known construction of circuit-closer, which had been thoroughly tested, and was considered by the patentee the best, though by no means the only apparatus for the purpose, which was at that time available.

Prof. Morton also further says, in fol. 611, in his answer to int. 8, that he conceives the general arrangement of conductors proposed in the patent to be a very bad one, and calculated to interfere with the successful operation of the system on a practical scale. In respect to this point, it is my opinion that the proposed arrangement of conductors will accomplish the desired result as well as any other that could possibly be devised, the only question between it and other arrangements being one of expense of construction, not of efficiency of operation. Substantially the same arrangement of circuits as that shown in the patent is now in successful use, as I am informed and believe, on the Harlem railroad, in New York city.

Referring to Prof. Morton's statements, in fols. 612, 613, and 614 of defendants' evidence, I say that it is not at all necessary that the magnets should all be made alike, as it would be quite possible to so construct them that each magnet would have the same lifting or pulling power without reference to the strength of current passing through it, and thus dispense with the necessity of equalizing the resistances. Practically, it is, of course, much more convenient to make them all alike and equalize the strength of current in the various subsidiary circuits. The matter contained in the sentence in fol. No. 614 I will answer hereafter. (See p. 95, fols. 377–382, *post*.)

In the sentence numbered fol. 615, Prof. Morton, in my opinion, misinterprets the meaning of that clause in the specification of the patent which reads as follows: "In cases where it is required to operate a large number of signals, extending along the road for a distance of many miles, the two conductors C and Z may be extended

the entire distance and a number of batteries attached at convenient intervals, say, for instance, from five to ten miles apart.
114 The several batteries should all be placed with their positive poles in connection with the wire C, and their negative poles in connection with the wire Z, when they will virtually form one large battery and the principle of operation will remain the same as that hereinbefore described."

I conceive the true interpretation of this sentence to be as follows: Experience shows that it is not economical or convenient to operate a series of signals from one battery when the most distant signal is more than from five to ten miles from the battery. Therefore, a person carrying out the plan as described in the patent, would naturally proceed to construct a system of signals and circuits for operating them, extending over from five to ten miles of road, or as far as the signals could be conveniently and economically operated. He would then construct an exactly similar system covering the next five or ten miles of road. But this clause in the specification informs him that he may make the battery conductors continuous over two or more sections and attach the batteries of the several sections thereto. The practical advantage of this modification is that any deficiency or accidental weakness on the part of any one battery is practically supplemented by the other battery or batteries. That is, they, to a certain extent, assist each other, for the reason that each individual signal when operated receives its supply of electricity from the combined action of all the batteries in the system.

It is on the same principle that it is usually better to heat a long room with two moderate sized stoves near the ends, than one large stove placed at some one point.

Referring to the sentence fol. 616, I consider the defendants' inventions, so far as patented, in public use or described in printed publications, to be thenceforth a part of the state of the art.

Referring to the answer to int. 9, I say that there was no necessity, at the date of complainants' patent, of describing in detail a method of equalizing the resistance of the different circuits any more than of describing the particular means of insulating
115 the wires on the poles, every electrician having been for many years perfectly familiar with both. In fact Prof. Morton himself says, in answer to cross-int. 64, fol. 800, that the use of resistance coils for this purpose must without question have been familiar to every one acquainted with the art of applying electricity to the working of automatic railway signals.

In the answer to int. 10, fols. 619, 620, Prof. Morton says the cost and difficulty of even attempting to insulate the rails from each other or from the ground would be very great, and, even if accomplished, would be very difficult to maintain during wet weather, etc. In reply to this, I say that an experience of some years has amply demonstrated that no necessity exists of insulating the rails used as circuit-closer from the ground further than they are already insulated by the wooden ties, and gravel or broken stone ballast, on which these usually rest, as railroad tracks are ordinarily constructed.

The insulation of the rails from each other does not cost $5 for

each signal, which is far cheaper than any other form of circuit-closer can be made, which will perform the same function.

Referring to the paragraph numbered fol. 622 of the answer to cross-int. 46, fol. 749, in which latter Prof. Morton says that the resistance coils for equalizing the circuits would have to be readjusted whenever any change was made in the length of the line, number of signals, and the like, I say that there is seldom, if ever, any necessity for making a change in the length of the line after it has been once established, and that on a line of a given length it is not true that a change in the number of signals would necessitate any change in the resistance of the remaining circuits. The only change required would be in the battery power, and this only in case there was an increased liability of two or more signals in the system being set in operation at the same time. Resistance coils, such as would be suitable and proper for the purpose indicated in the patent, are not very expensive pieces of apparatus, being made of iron wire of the size known as No. 20, overspun with cotton thread, and costing about forty cents a pound. It is sold
116 under the commercial name of bonnet wire. For a circuit of ten miles, five miles and return, such as the one between Salem and Lynn, described in the testimony of Alvah W. Hall, fol. 111, and which he says, in answer to cross-int. 67, was composed of Washburn & Moen's galvanized No. 9 wire, the electrical resistance of which would be about 161 electrical units; the largest and most expensive resistance coil required could be made of nine pounds of cotton-covered No. 20 iron wire, costing about $3.50; and the only adjustment required would be to cut off the proper length of it and wind it up loosely on a spool, which could be done in half an hour at the outside. The electrical resistance per mile of an iron wire can be ascertained, when its weight per mile is known, by the simple and well known rule of dividing the constant number 4884 by the weight per mile in pounds; or the number of pounds per mile equivalent to a given number of electrical units may be found by reversing the process. Consequently, the only instruments which an intelligent mechanic would need to adjust these resistances, provided he was familiar with the rule I have given, would be a suitable pair of scales and a rule for linear measurement. I cannot imagine what is meant by the alleged liability to derangement which Prof. Morton speaks of in connection with these resistance coils, and cannot conceive of any possible way in which a simple coil of iron wire can get out of order. It is true, if made of very fine wire, the resistance coils might become overheated by the passage of powerful currents through them; but I, of course, assume that any person sufficiently well informed to be placed in charge of such work would know enough to use the proper sized wire in constructing the coils.

Referring to the answer to int. 11, I consider the circuit-closers of the apparatus shown in Exhibit C as equivalents of those described in complainants' patent. Either of these forms of circuit-closer may be substituted for the other in the combination without in the least affecting the result.

Referring to the paragraph fol. 625, it is sufficient to say that the

117 particular means which may be adopted to render the currents in the subsidiary circuits substantially equal to each other form no part of the complainants' patented invention, this being a matter which may be properly left to the judgment of an intelligent constructor.

Referring to the plan shown in Exhibit C, fol. 627, the witness Morton says: That the conductor Z, or, as it is called, the negative conductor, has no connection with the battery. This statement is incorrect. This conductor is electrically connected with the negative pole of the battery by means of the earth, which in this case acts as a conductor of very little resistance. If it were true that the negative conductor had no connection with the battery, then it would be impossible to complete the circuit by forming the connection between it and the positive conductor C. At fol. 629 he says, that as "both the conductors C and Z serve to carry the positive current in the same direction away from the battery. They should, therefore, both be properly called positive conductors." In respect to this, I say that there is no difference between a positive current going towards a battery and a negative current going from it. The terms positive and negative are purely arbitrary and conventional, and the two different expressions just referred to are two ways of expressing the same fact, as Prof. Morton himself says in his answer to redirect int. 66, at fol. 821.

As soon as the circuit, which is normally open, is closed at any point, and positive current passes into the conductor Z, it may properly be said to commence its return course to the opposite pole of the battery, notwithstanding the fact that the first part of its course is, geographically speaking, in an opposite direction.

Referring to the answer of the witness to int. 12, I say that the English patent of Bianchi, although it contains, as the witness states, a single battery, in combination with two or more instruments for interrupting and renewing electric connection, in combination with two or more electro-magnets, actuating, or causing to be actuated, visible or audible signals; these signals, as described in the patent, are not capable of attracting the attention of an engine driver,

118 but are merely small dials or indicators, one of which, as the patent states, is intended to be placed in the station master's office at each end of the section of railroad to which they belong. Without taking this into consideration, however, I say that the various elements are not combined in the same manner, nor are they capapable of producing the result which professes to be the object aimed at by the invention set forth in complainants' patent. In Bianchi's arrangement, each and every circuit-breaker along the line of the railroad, when acted upon by a train, simultaneously actuates all the signals in the system; whereas in complainants' patent each signal is exhibited by its own individual circuit-closer, and no other, and the signals are exhibited, not simultaneously, but successively, and in their proper order, and this is essential to the production of the desired result. This is admitted by Prof. Morton in his answers to cross-ints. 54, 55, 56, and 57.

Referring to Prof. Morton's answer to int. 13, fol. 652, he states

that he finds in the English patent of Wm. Bull circuit-closers consisting of insulated sections of rail. This is only one element of the combination of complainants' patent, and is not therein claimed to be new.

Referring to the same witness' answer to int. 14, he says that he finds in the British patent of Clark the combination of a battery, conducting wires and electro-magnets for reversing signals, with circuit-closing apparatus placed at intervals along the line of a railroad; also the locking, or holding in position of the danger signal until released by said electro-magnet.

Upon examining the patent of Clark, I find that each signal is worked by a separate and independent battery, and the witness himself says, in answer to cross-int. 58, that he does not find therein the combinations constituting either one of the three claims of complainants' patent.

Referring to the same witness' answer to int. 15, I can find nothing whatever corresponding to the combinations claimed in the complainants' patent.

It is nowhere stated in the specification that two or more signals, situated along the line of a railroad, may be operated successively by the same battery.

119 Referring to the answer of same witness to int. 16, he says that he finds circuit-closers for actuating signals, consisting of insulated portions of rail, etc. I remark that is not claimed to be new in the specification of complainants' patent, and there is nothing whatever in the specification of Barnes & Hancock to indicate that two or more circuit-closers are to be connected with one and the same battery.

(Defendants' counsel objects to so much of the answer at foot of MS., page 166, fol. 368, as describes, on information and belief, certain apparatus on the Harlem R. R., as hearsay.)

Int. 14. In the absence of defendants' exhibits, spoken of on pages 173 to 176, please pass on to fol. 687, and state whether or not, in your judgment, assuming the existence of such a system as is represented by Defendants' Exhibits Nos. 5 and 6, it would involve invention to equalize the unequal resistance of the various circuits therein shown by any of the well-known means, such as resistance coils or the like, for equalizing resistances, and give your reasons for any opinions you may express.

Ans. In my opinion, it would not involve any invention to do this, after the suggestion had been made that it should be done. There may possibly be some invention in the suggestion itself, because it points out a means of overcoming a practical difficulty, of more or less importance, according to circumstances. I agree with Prof. Morton, in his answer to int. 22, that "prior to any experiment with such a system, it would be perfectly plain that these differences of resistance in the various circuits would exist;" but I do not agree with him when he says that "it would not follow, until established by experiment, that they would necessarily interfere with the successful working of the system on a practical scale." In

my opinion, any electrician having the slightest pretensions to a knowledge of his profession, would not need to make a practical experiment to ascertain the fact that a battery having sufficient power to operate a visual signal of any of the usual forms
120 through, say, ten miles of No. 9 wire, would certainly injure the circuit-closers and magnets of a similar signal apparatus close at hand. Knowing this, it would be equally plain to him that the insertion in the circuit of the last-named signal of a resistance equivalent to the ten miles of No. 9 iron wire would make it operate under precisely the same conditions that the distant one would. The size and weight of the wire required to form this resistance could be determined by the very simple process of calculation which I have given in answer to int. 13, fol. 380, of printed testimony.

Int. 15. Please refer to int. 23, fol. 690, of defendants' evidence, and answer the questions therein addressed to Prof. Morton, and give your reasons for any opinion you may express.

Ans. The suggestion having been made that the resistance of the subsidiary circuits of Defendants' Exhibits Nos. 5 and 6 should be made equal, I do not consider that it required any more invention to apply one well-known method of accomplishing this result than to apply another.

Int. 16. Please turn to fols. 698, 699, and 700, defendants' testimony, and state whether or not the absence in complainants' patent of any arrangement corresponding with the arrangement set forth in Defendants' Exhibit 40 as a means of making all the circuits of equal length and resistance, is or is not material or important to the validity of the complainant's patent, and the claims therein made.

Ans. I do not consider that the particular method which might be adopted of equalizing the circuits has anything to do with the subject-matter claimed as new in the patent. It does not make the slightest practical difference in the working of the signals, nor in the expense of keeping them in operation, whether one method or the other of equalization is adopted. Whatever difference there is in the two systems would consist: First, in the difference of the original cost, which would be somewhat greater if the circuit was composed entirely of wire; and, second, in the liability to accidental interruption, as, for example, from contact with other par-
121 allel wires which would be greater in the case of a circuit composed partly of the earth. It should also be stated that the earth may be employed in place of one of the conductors, C or Z, in the complainants' patent, without departing in the least from the general principle of the invention, it having been for many years a common practice to make use of the earth as a return conductor in all sorts of systems of electrical apparatus.

The question whether to make use of the earth or of an insulated metallic conductor to complete the circuit in any given case, is one which is determined solely by considerations of first cost or of convenience; one of them is well understood to be an equivalent for the other.

Int 17. State whether or not the element of certainty in the work-

ing enters into this question, in view of such experience in reference to possible interruptions from geological formations, as you have referred to in a previous answer, or from other causes.

Ans. Yes; it is sometimes a very material consideration; it would be absolutely impossible to operate a system of signals in which the earth formed a part of the electric circuit, under the conditions which I met with at Sunbury and Northumberland, Penn., in 1872, and which I have described more fully in a previous answer, fol. 269; although this phenomenon was new to me at that time, I have since ascertained by comparing notes with other principal electricians, that it is not at all an uncommon one, and has been observed in a number of cases in New Hampshire, Vermont, and Pennsylvania. The precise cause of it is not as yet very well understood; my own theory on the subject is that in some of these cases, at least one of the terminals of the line is situated in a sort of a basin of non-conducting rock, such as granite or quartz, which is filled with earth; while the other terminal of the line is outside of such basin; this, however, did not appear to be the case at Sunbury, and I am still at a loss to satisfactorily account for the facts observed there; usually this effect is observed in rocky portions of the country; to insure absolute reliability in working electrical circuits it is
122 better not to use the earth at all as a conductor; for this reason for fire-alarm telegraphs, district telegraph signal systems, &c., are always insulated completely from the earth at all points.

Int. 18. Considering the state of the art prior to your application for complainants' patent, would it or not involve invention to arrange two or more circuit-closers with magnets for operating signals, and two or more circuit-closers with magnets to withdraw the same signals along the line of a railroad, in connection with a signal battery, and conductors C and Z attached to the positive and negative poles respectively of the battery, and had or had not Mr. Hall, or any other person at the date of that application, developed by practical experiment such a system?

Ans. I consider that it involved invention to do this at the date of the complainants' patent. Extensive systems of automatic signals had been put in operation by Mr. Hall, a year or two prior to this date, on the New York and Harlem railroad, and on the Eastern railroad in Mass., in which each signal was operated by a separate battery, and in the latter instance, at least, had, after working for a while, been discontinued in consequence of the difficulty of keeping so many batteries scattered at so many different points in proper working order. It appears from the testimony of Mr. Hall and Mr. Snow that such a system as is described in your interrogatory was not developed by them in a practical experiment until February, 1874. The complainants' invention consisted in a new and improved mode of combining circuit-closers, electro-magnets for operating signals, and electric conductors with one and the same battery in such a manner as to produce a result already known in a more efficient and economical manner, this result being the operation of these signals, automatically or otherwise, in definite and pre-

determined succession corresponding with the progress of a train along the railroad.

Int. 19. Do you or not consider the inventions and experiments made by Mr. Hall, and all other persons, and patented or in public use, a part of the state of the art that should be known to a competent electrician?

123 Ans. I should regard everything which had been patented, described in printed publications or actually in public use, as distinguished from private or experimental use, no matter by whom invented or made, as a part of the state of the art with which a person skilled therein is assumed to be familiar. I do not mean to say that any person would have a right to use inventions thus patented; but any person certainly has a right to patent a novel and useful improvement on an invention which has been already patented by another person, and to proceed to put his improvement in use, either by acquiring the right to use the original machine from the owner of the patent, or by waiting until the earlier patent had expired, and then working it in connection with his improvement.

Int. 20. Do you know whether or not electric visual signals of suitable construction to be placed along the line of a railway, which were capable of being put in action or exhibited by the action of one electro-magnet, and reversed or concealed by the action of another electro-magnet, substantially in the manner and for the purpose set forth in complainants' patent, were known or in public use at the date of said patent, namely, July, 1873?

Adjourned to February 19, 1879, 10 a. m.

Ans. I do.

Int. 21. State all you know about that matter.

Ans. The specifications and drawings of the British patent of of Johnson, Complainants' Exhibit M, contain a full and sufficient description of a visual signal, which is exhibited by the direct action of one electro-magnet, so arranged as to remain thus exhibited after the circuit through the actuating electro-magnet has been interrupted, and reversed or concealed by the direct action of a independent electro-magnet. This specification and drawing purports to have been published in 1858. Signal machines containing all these features in combination were also constructed under

124 my direction in October, 1871, one of which was publicly used on the Boston and Lowell railroad, at Boston, from the 9th of November, 1871, till the last of February 1872, and I think some weeks longer. Other signal machines containing the same devices were constructed in November and December, 1872, under my direction, and were publicly used at Bethlehem, Penn., commencing in December, 1872, and continuing for some weeks; also at Bear Creek, Penn., commencing in the spring of 1872, to the best of my recollection, in March, and continuing in constant operation through the greater part of the remaining portion of that year; both of these applications being on the Lehigh Valley railroad. Also on the Baltimore and Ohio railroad, near the city of Baltimore,

commencing in March, 1873, and continuing in constant operation for six months at least.

Int. 22. State whether or not the general arrangements for the use and operation of the invention described in Johnson's patent, named by you, and also named in answers to cross-int. 35 and cross-int. 39, to Prof. Morton, were such as, in your opinion, would work successfully in practice, and give reasons for your opinion?

Ans. I do not consider that an intelligent and skilful mechanic would meet with any difficulty whatever in constructing an operative signal machine, by following the drawings and directions contained in that patent. The specification says that the signal proposed to be used consists, among other thing, of a colored glass (marked D in the drawing), but says that "various modifications thereof may be employed," a very obvious modification being the substitution of colored cloth for colored glass, which would considerably diminish the necessary weight of the signal-disc and its counterbalance. This would somewhat reduce the friction upon the fulcrum which supports the disc, and enable it to be moved with somewhat less magnetic power, and also somewhat more quickly, but the machine would, nevertheless, in my opinion, operate perfectly well if constructed precisely as described in the specification. It is true, as
Prof. Morton says in his answer to cross-int. 39, that "whatever
125 force is needed to give motion to the disc, 48 times as much force would need to be applied by the magnets;" but this is also true of the signals invented and used by Mr. Hall, of which Complainants' Exhibits E and F, and Defendants' Exhibits 16 and 17 are examples.

In these signals of Mr. Hall's the diameter of the colored disc is about fifteen inches, and in order to cause the disc to be be exhibited or concealed, it must necessarily be moved through a distance equal to its own diameter. Now, as it is not practicable, or, at least not advantageous to arrange an armature in connection with a magnet of the size used on Mr. Hall's machines, so as to require the armature to move when attracted a greater distance than about one-third of an inch, it is obvious that Mr. Hall's arrangement requires the exertion of at least forty-five times as much power by the magnet as is necessary to move the disc. I do not consider this, however, a practical objection in either case. In fact, all other conditions being equal in the Johnson and in the Hall machines, by which I refer to diameter and weight of signal disc, distance through which it is to be moved, size, and construction of electro-magnet, and distance through which the armature is to be attracted, the Johnson machine would require less power than the Hall machine, for the reason that in the Hall machine the signal disc is returned to its normal position by the action of gravity, and, therefore, this weight must be lifted in addition to the power actually required to move the signal, whereas in the Johnson machine the counterbalance must be so adjusted that it will keep the signal at rest in whatever position it may be placed, while the mechanical work of returning the signal disc to its normal position is performed by the action of an independent electro-magnet.

Int. 23. Referring solely to the mechanism shown in Exhibit M, referred to in Prof. Morton's answer to cross-int. 40, state whether or not, in your opinion, said mechanism would operate successfully, provided electric currents of sufficient strength and sufficient duration were sent through the coils of the electro-magnets?

Ans. I think it would operate perfectly well, and in con-
126 firmation of this opinion would say, that the signal machine of Mr. Hall, Complainants' Exhibit F, has been operated in a perfectly successful manner according to testimony of the defendants' witnesses, and the only material difference between the Hall and the Johnson machines in this respect is in the particular mechanical devices for connecting the armature with the signal-disc and multiplying the motion of the armature so as to move the signal-disc the required distance.

Int. 24. Assuming an operative signal to have been constructed in accordance with the description contained in Johnson's patent, that is to say, the signal exhibited by the action of one electro-magnet and reversed or concealed by the action of another electro-magnet; state whether or not, in your opinion, it would require invention as distinguished from the knowledge which should be possessed by a person skilled in the art, to place such signal in the combination of circuits described in the complainants' patent.

Ans. None whatever. The machine described in the Johnson patent contains the two electro-magnets, one marked J for exhibiting the signal and one marked K for reversing or concealing it. These correspond to the magnets M and *m* in the drawing annexed to complainants' patent, which gives explicit directions and illustrations, showing how they are to be connected with the circuit-closers and the battery in order to operate in the combination.

Int. 25. Please examine patent No. 129,425, Complainants' Exhibit O, especially the second column of the second page, also the English patent to Wm. Robert Lake, No. 2461, Exhibit P, and say whether or not, in your opinion, a sufficient description is given in each of said references severally of a method of insulating from each other the abutting ends of two adjacent rails, which, taken in connection with the accompanying drawings, would enable a person properly skilled in the art to effect the desired result?

Ans. I have examined the patents referred to, and say that the description and drawings are sufficient for the purpose stated.
127 In proof of this I will state that in 1872, at the request of Mr. H. S. Goodwin, of the Lehigh Valley railroad, who was anxious to try one of our signals on his road, and to facilitate this trial proposed to insulate the track himself. I prepared and sent to him, at Bethlehem, Penn., drawings or tracings of figs. 4 and 5 of the drawings accompanying patent No. 129,425, and a description thereof, substantially the same as contained in the specification of said patent, and without further instruction or information Mr. Goodwin, or his employees, did insulate certain sections of the track at or near Bethlehem with vulcanized rubber, precisely in the manner shown in the drawing of said patent 129,425. In October, 1872, as heretofore stated in the testimony of myself and Mr. Hendrickson, we attached

a signal to the portions of track thus insulated by Mr. Goodwin, and found the insulation sufficient and satisfactory, and the signals worked continuously thereby for several months thereafter.

(Defendants' counsel object to so much of the answer as states that witness sent on to the Lehigh Valley railroad a description of his apparatus, which was substantially the same as that given in the specifications of his patent, for the reason that it is secondary evidence and matter of opinion.)

Int. 26. Please state wherein, if at all, description of the apparatus so sent on by you differed from that described in your patent.

(Objected to, as calling for secondary evidence and matter of opinion.)

Ans. I do not recollect the exact words of the description I then sent on, and cannot, therefore, state the difference in detail. To the best of my recollection, I sent Mr. Goodwin a tracing of the necessary parts of the original patent drawing, accompanied simply with directions to insert vulcanized rubber in the rail joints in the manner shown by the heavy black lines in the drawing. I depended principally upon the drawing itself for giving him the idea.

128 Int. 27. Please examine the answer of Prof. Morton to cross-int. 43 and state whether or not, in your opinion, a successful permanent insulation would be produced by the means named in your answer to int. 26. Please examine his reasons for his opinion, and if you differ from him give your reasons for your differing opinion.

Ans. The gist of Prof. Morton's answer to cross-int. 43 consists in the statement that, "though, of course, this mode of insulation would work for a time and under favorable conditions, it could not be relied upon under conditions of practical use." In reply to this, I say that this mode of insulation worked successfully for two or three months at Bethlehem, Penn., under all kinds of conditions usually met with in practice, including rain, snow, slush, and frosty weather, and the insulation never failed in a single instance. When we discontinued the application at Bethlehem the same apparatus, with the exception of the circuit-closers or the track insulation, was removed to Bear creek. At the latter place, however, a different method of insulation of the track joints was adopted, being one similar to that shown in fig. 6 of the British patent of William Robert Lake. The reason for making this change was not because the second plan of insulation was any better than the first in an electrical point of view, but simply because it was cheaper and easier to construct with the materials usually found about the shops of a railroad, and was more solid and substantial in a mechanical point of view. For these reasons we have since employed the second plan exclusively

Int. 28. Please examine the system of circuits and circuit-closers shown in Complainants' Exhibit C and state whether, in your opinion, it would or would not make any substantial difference in the principle of its operation or the results obtained if a metallic conductor, insulated from the earth in the same manner as the conductors C

and Z, were substituted for that portion of the circuit which is formed by the earth, as shown in diagram Exhibit Q, provided a sufficient number of elements were added to the battery to
129 enable it to actuate the signals through the additional resistance which would be caused by the substitution of a metallic conductor. Please examine the answers given by Prof. Morton to cross-ints. 48 and 49, and if you differ from his opinion there given please state the reasons therefor.

Ans. I do not consider that it would make any difference in the principle of the system by substituting one material for another for the return conductor; nor would it make any difference whatever in the practical results obtained. The difference would be merely in the first cost of construction of the additional metallic conductor, and the additional elements of battery required to produce the same effect through the additional resistance offered by the metallic conductor.

Int. 29. Can you state what would be the additional cost per mile in substituting the metallic conductor? I mean the first cost to which you allude in your previous answer.

Ans. I can give it very nearly. Taking, as an example, the system of signals between Salem and Lynn, described by defendants' witness, and which is stated to be five miles in length, with battery conductors composed of No. 9 galvanized iron wire; suppose it were required to reconstruct this, using precisely the same arrangement of circuits as that now used there, and which is shown in Complainants' Exhibit C, with the exception that a metallic conductor is substituted for the earth, thus making it conform to Complainants' Exhibit Q. To produce the same effect or result, without an increase of the battery power now used, it is only necessary that the total resistance through which the battery current has to pass to operate any given signal should not be increased. This result would be accomplished if No. 6 iron wire, a size now very commonly used in telegraphic construction, were used to replace the existing No. 9 wires, and the third, or return conductor, were also constructed of No. 6 iron wire; then this would be the case, because the resistance of No. 6 iron wire per mile is, as nearly as possible, half that of No. 9 wire.

The difference in cost per mile, between No. 6 and No. 9,
130 is about $7. The cost of a new No. 6 wire and the putting it up is about $40. This would make the total expense about $14 per mile extra, for using No. 6 wire, instead of No. 9, and $40 for the new wire—making the total cost about $54 more per mile of railroad. I do not pretend that these figures are strictly accurate, but they are within a very few dollars more or less of what the actual difference in cost would be between the arrangement shown in Exhibit C and that shown in Exhibit Q.

(It is agreed that the complainants' time to take their testimony in rebuttal be extended to March 10th, and that the defendants have until March 20th to take their testimony in reply, and that the examiner in this case may sit in the city of New York and Newport, R. I., to take testimony herein; and that the testimony

taken in said place, by said examiner, may be received and used in the trial of this case, with as full effect as if the same were taken in this district; and it is also agreed that the testimony of A. G. Davis, a witness for the complainants, may be taken at Baltimore, at such time and before such magistrate as shall thereafter be agreed upon by the parties.)

Int. 30. Please state why C is designated as the positive, and Z as the negative conductor, in such a system of circuits as that represented by Ex. C. Please examine Prof. Morton's answers to cross-ints. 52 and 53, and if you differ from him, give reasons for your opinion.

Ans. The circuit or system of circuits represented in Exhibit C is that technically known as an "open circuit," which may be described in general terms as a battery, having a conductor or connected series of conductors attached to and electrically connected respectively with the positive and negative poles of the battery. The action of the battery under these circumstances produces a difference of electrical condition, between the two sets of electrical conductors referred to, which are commonly called the positive and negative states; these being arbitrary terms and used for convenience
131 in explanation. When a conducting connection is formed between any point in one series of conductors and any point in the other series of conductors, the circuit of the battery is said to be completed, and is, in fact, completed, and an electric current traverses the conducting connection. This being the state of the case in all open-circuit systems so called, I consider it to be entirely proper to designate all the conductors between the point or points where the circuit is normally interrupted and the positive pole of the battery, and which are permanently connected with and in electrical connection with that pole, as *positive conductors*, and all conductors between the point or points where the circuit is normally interrupted and the negative pole of the battery, and which are electrically connected with the latter pole, as *negative conductors*.

Prof. Morton, in his answer to cross-int. 52, fols. 775 and 776, referring to Exhibit Q, says that he considers the wire Z to be properly a positive conductor, and the red line in the same exhibit to be the only wire that can properly be called a negative conductor. It is obvious that as the wire Z and the wire represented by the red line, when taken together, constitute one continuous and uniform conductor, traversed from one end to the other by the same current, that they are actually and in fact the same thing, whether called by the same or different names, and being in electrical connection with the negative pole of the battery, it is properly termed a negative conductor, for the reason above stated.

Int. 31. Assuming the amount of battery power required to operate the most distant signal upon a circuit to have been determined as Prof. Morton says it might be, in his answer to cross-int. 60, could a competent electrician be expected to predict what the effect of such power would be when employed to operate a similar signal apparatus and its circuit-closer, when the resistance of ten miles, more or

less, of wire had been removed from the circuit? Please refer to answers of Prof. Morton to cross-int-. 61 and 62 before concluding your answer.

Ans. A competent practical electrician would certainly be able to anticipate or predict this difficulty without making an actual experiment to ascertain the fact. Such was anticipated by the inventor of the system described in complainants' patent, and directions are given in the specification to equalize the resistance of the various subsidiary circuits and thus avoid the said difficulty.

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Int. 32. Please refer to and examine Prof. Morton's answer to cross-int. 64, and state whether or not you agree with him in the statements therein made in answer to said interrogatory; and, if not, give your opinions, with the reasons therefor.

Ans. The general tenor of Prof. Morton's answer to cross-int. 64 I conceive to be, that the use of resistance coils must have been familiar to every one acquainted with the art of applying electricity to the working of signals, while the method of accomplishing the same result, as shown and described in section 83 of Mr. Pope's book, Complainants' Exhibit R, was not an equally well-known method. In reply to this I say, that, in 1874, this book had been five years before the public, and, to my personal knowledge, several thousand copies had been sold in the United States. It, therefore, must have been tolerably familiar to most persons having to do with practical electrical work. Prof. Morton says, in reference to the arrangement of circuits shown in Exhibit R, that "it does not appear that the equality of resistance of the connecting wires was any part of the object aimed at in said arrangement, but was simply an accident, the equality sought being that of the instruments, as appears from the language of the description in section 83, where Mr. Pope says: 'Every sounder in the combination should have the same amount of wire in its coils, as nearly as possible, in order to secure the best results.'" In reference to this I say, that no other object than an equality in the resistance, and consequently the strength of current flowing through the several subsidiary circuits, was aimed at in arranging the circuits in the manner shown. The directions quoted in reference to the equality of the sounders is equally applicable and equally necessary to be observed in the case of a system of signals arranged in a circuit like Exhibit C or Exhibit Q, or Defendants' Exhibit No. 8. In reference to that portion of Prof. Morton's answer, between fols. 803 and 804, I cannot agree with the statement he therein makes. For example: In a room 100 feet long, like that formerly occupied as an operating room by the American Telegraph Company in New York city, and where the sounders were at one time worked in a combination from a single battery, the instruments being distributed along the whole length of the room, and the battery wires being the ordinary conductors used in such cases—that is, No. 16 copper wire—the difference in resistance between the circuit of the sounder nearest the battery and the one the most distant would be at least half a unit. The resistance of the sounders themselves being usually about two units, this would

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make a difference of about twenty per cent. in the working force of the two instruments, unless compensated in some manner, and to effect such compensation or equalization was the sole object of the arrangement described and shown in Mr. Pope's book, which was formerly very much used in American telegraph offices, though of late years superseded by other arrangements. Thus, it is certain that this was not an "accidental and unobserved condition," as Prof. Morton thinks. Referring to the paragraph of the same answer numbered fol. 807, I say, that the particular arrangement to be adopted for equalizing the circuits forms no part of the invention described in complainants' patent, as in some cases it would work just as well practically without any equalization. I do not understand that a patentee is required to describe every possible way of performing a well-understood operation, especially if it forms no part of the invention claimed by him.

Int. 33. I call your attention to p. 208, defendants' evidence, fols. 813 and 814. Please examine the statements therein made in answer to cross-int. 65, and say whether or not you agree with these statements, and if not, state your opinion, with your reasons therefor.

Ans. I do not agree with Prof. Morton in the statements therein made, for the reasons which have been sufficiently explained in a previous answer—page 110, fol. 437–440.

I consider the conductor B, in Defendants' Exhibit 40, to
134 be strictly anal*a*gous or equivalent to the conductor Z, as a virtual prolongation of the negative pole of the battery, being as it is in conducting connection with the said negative pole by means of the earth, which has long been known as an equivalent for a metallic conductor, when employed to form part of an electrical circuit.

Int. 34. Please state whether or not it would be practicable to supply a metallic conductor, having no more resistance than the earth, in constructing a system of electrical signals along the line of a railroad; and would a system involving such a return wire be practically the same as one involving connection with the earth at either end, or how otherwise? Please refer to Prof. Morton's answers to cross-int. 50, and redirect int. 66, and if not, give your opinion and reasons for the same.

Ans. Although it is true, as Prof. Morton states, that the resistance of the earth is immeasurably small, or practically nothing, yet it is equally true that it is very difficult to form a connection between the earth and a metallic wire which does not offer considerable resistance. In cases where the wire can be connected to an extensive system of gas or water pipes, having an enormous surface of metal in contact with the earth, this resistance is small, and only amounts to a very few units. In cases where no such system of pipes is available, and this must necessarily be the case at many points where signal circuits are required to be terminated, the usual and most practicable plan to be adopted is to bury a considerable surface of metal in contact with the earth, and connect the wire to the metal. The resistance at the point of contact between the metal and the

earth is small in proportion as the surface in contact is great. But the resistance of such an arrangement of any practicable dimensions is considerable. I have rarely or never, so far as I can recollect, measured one that gave less than thirty units of resistance, which would be equal to about two miles of No. 9 wire. Practically, therefore, the resistance of the earth, when used to complete a circuit of five miles, like that between Lynn and Salem, described by defendants' witnesses, would be equal to about four miles of the
135 wire used, unless gas or water pipes were used to make the connection with the earth. In most cases I do not think it would make much practical difference in a five-mile circuit whether the earth or a No. 9 wire was used to complete the circuit. In my former answer, page 109, fol. 433–4, I have given an estimate of the difference in cost between the two systems, where the total resistance of the circuit was made the same in each case. It would amount to about $540 for ten miles, as near as I can get at it, and the important advantage would be gained of having the entire system insulated from the earth, so that no accidental contact between the signal wires and adjacent telegraph wires, or other similar metallic conductors, would interrupt or interfere with its working. Another important consideration is that a system of circuits insulated from the earth does not form a lightning conductor like a system which has a good connection with the earth, and, therefore, there is much less liability of the danger signals being released or reversed by the action of atmospheric electricity. I further remark that the earth may just as well be used in place of one of the wires of the system described in complainants' patent, Exhibit A, and this without in the least departing from the principle of the invention. In this case it would require only one-half the length of line wire to accomplish the same result that it would in the arrangement shown in Defendants' Exhibit No. 40. I have seen such an arrangement actually at work.

Int. 35. Please refer to Prof. Morton's testimony, on page 212, commencing at fol. 829, and review the differences which he points out between the different systems, and give your own opinion upon the same matter, and if it differs from his, give your reasons.

Ans. Referring to the diagrams, Figs. 1 and 2, on pages 210 and 212, defendants' testimony, Prof. Morton says that the arrangement shown in Fig. 2 in practice saves about half the battery power used in working the system. This would only be true in case there was no resistance in the earth connections, a condition which, as I have stated, fol. 451–4, it is very difficult, if not impossible, to se-
136 cure under ordinary circumstances. Even if the earth circuit was entirely without resistance, half the battery power required might just as well be saved by using a conducting wire of twice the sectional area, but not costing anything like twice the amount, and other important advantages would be gained, as I have stated.

Adjourned to February 20, 1879, 10 a. m.

HARTFORD, CONN., *February* 20, 1879.

Met pursuant to adjournment.

Parties represented as before.

Testimony of F. L. Pope—Continued.

Int. 36. Please recur to the testimony of Prof. Morton, commencing at fols. 676, p. 173, int. 17, and continuing on pp. 174 and 175. Please make comparisons, with such illustrations as may be necessary, between complainants' patent and defendants' several exhibits, referred to in ints. 17, 18, 19, and 20?

Ans. Referring in the first place to Defendants' Exhibits, No. 1 A, and Nos. 4, 9, 27, 36, and 41, in which the arrangement and construction of the several parts and mode of operation is substantially the same; these may be conveniently included in one description. The visual signal used in all these applications is that represented in Complainants' Exhibit F; T. S. Hall's patent, No. 103,875. It consists of electro-magnet A, whose armature is attached to the short arm of the lever *h*. The end of the long arm of this lever *h* is connected by means of the rigid rod *b*, with the short arm of a second lever *c*, the long arm of which latter lever is attached by means of a cord *d*, with a pulley *e*, on a shaft *f*, from which projects an arm *g*, which carries the signal-disc F, and a counterbalance *t*. When an electric current passes through the coils of the electro-magnet A,

137 it attracts its armature E, which through the intervening mechanism I have described, swings the signal-disc into a displayed position by its own movement toward the poles of the magnet. The motion is so multipled by the arrangement of the leverage, that the movement of the signal-disc is, perhaps, forty or fifty times as much as that of the armature, and consequently some little time is required to exhibit the signal after the electric current is applied to the magnet; say, from three to six seconds or more, according to the strength of the current.

Thus the effect of this armature being attracted to its magnet by a constant current of electricity passing through its coils, is to display the signal disc F, and keep it in position as long as the current continues, but no longer. As soon as the current is interrupted, the disc F drops back to its normal position by its own weight. Thus the signal used in these applications required the continuous application of an electric current for several seconds, in order to cause it to be displayed, and it would only remain displayed so long as the current continued, it not being provided with any device for retaining the disc in a displayed position, after the actuating current had been interrupted.

The apparatus for closing the electric current by a moving train which was employed by the several applications represented by the exhibits referred to, is that represented in Complainants' Exhibit D, and is fully described in the testimony of A. W. Hall, in defendants' evidence, pp. 30 and 31, fols. 114 to 117. By reference to the description it appears that the circuit was momentarily closed by each wheel of the passing train. Thus it is obvious that if in any of these applications the circuit-closer actually used had been placed in direct electrical connection with the signal actually used, in the manner described in complainants' patent Exhibit A, no effect whatever could have been produced, because the circuit-closer could only

transmit momentary currents, while the exhibition of the signal required a continuous current.

The statements I have made in regard to the visual signal, in respect to the requirement of a constant current to keep it in action, are true also of the electric bell or audible signal.

138 In order, therefore, to produce the desired effect in these several applications, it was necessary to interpose between the circuit-closer and the signal or signals an apparatus which Mr. Hall calls a "double circuit instrument," of which Defendants' Exhibit No. 3, is an example. This consists of an electro-magnet to whose armature a small and light lever is attached, and which is placed directly in circuit with the track circuit-closer, above referred to. Owing to the lightness of the armature and lever of this magnet, it is capable of responding and does respond to every closure of the circuit by the track circuit-closer, however brief its duration. This armature lever is provided with a spring catch which slips under it and retains it in position the instant it approaches the poles of the magnet. Attached to this armature lever is also a circuit-closer connecting with a secondary battery and the magnet actuating the signal; also another circuit-closer placed in a circuit connecting with the alarm or audible signal; this last being a branch circuit from the same battery that operates the magnet of the double-circuit instrument.

The operation of reversing or taking off the audible and visual signals is performed by another track circuit-closer similar to the first one, and placed at another point on the railroad, which acts upon an independent magnet in the double-circuit instrument, which withdraws the spring catch or lock from the light armature lever, allowing it to fall back and thus breaking the continuous current of both the visual and audible signals.

It will be seen, therefore, that in each of these several applications, the effect or result, which is the causing of a signal to be exhibited or sounded continuously while a train is passing from one given point to another on the railroad and then discontinued or stopped, is produced by a combination of the following elements: first, an instrument which closes a circuit momentarily when struck by the wheels of a train; second, an electro-magnet, having a comparatively light and quick moving armature, and provided with a detent

139 for holding said armature in position after it has been once attracted by the magnet; third, a battery for actuating said electro-magnet, which is connected with it and the circuit-closer; fourth, an electro-magnet for actuating a visible or an audible signal or both; fifth, a circuit-closer or circuit-closers attached to the armature of the first-mentioned magnet; sixth, a secondary battery for supplying a continuous current for operating the visual signal, which is connected with the electro-magnet of said signal, and the last-mentioned circuit-closer. In the case of the audible signal, and considering its operation without reference to that of the visual signal, the third and fifth elements of the combination named are one and the same battery.

The combination thus far stated contains everything necessary to cause a signal to be exhibited or sounded.

In order to discontinue or stop the action of the signals the following additional elements are provided: Seventh, a second track circuit-closer, placed at some other point on the railroad; and, eighth, an electro-magnet for withdrawing the spring catch from the armature of the first magnet of the double circuit instrument.

In the apparatus which has been described every one of these elements is an essential factor in the production of the result. Take any one of them away and the whole combination becomes inoperative, unless the missing element is replaced by an equivalent device performing the same function. This combination is not found in the arrangement of complainants shown in patent Exhibit A, nor is it found in defendants' arrangement, as shown in Complainants' Exhibit C.

The same result that is produced by the combination just described is produced in the arrangement shown in complainants' patent by a different combination, consisting of the following elements: First, a track circuit-closer actuated by a moving train, but which closes the circuit, not momentarily, but continuously while the train is passing—that is to say, for a period of several seconds; second, an electro-magnet for actuating a visual or audible signal, which signal is to be provided with some suitable means of retaining it in position or action after the circuit through said magnet has been interrupted; and, third, a battery for vitalizing the said magnet, and which is connected with said magnet, and said circuit-closer. These are all the elements necessary to set the signal in action. In order to discontinue or stop the action of the signal the following additional elements are required: Fourth, a second track circuit-closer, similar to the first named; and, fifth, a second electro-magnet for releasing or reversing the action of the signal which had been started by the first-mentioned magnet. This being, if we include the necessary conducting wires, substantially the combination claimed in the third claim of complainants' patent, Exhibit A.

It is not only a different combination, requiring and containing a smaller number of elements to produce the same effect; but these elements themselves are not in all cases the same. For example, the circuit-closer in the several exhibits of the defendants referred to, is not an equivalent of the circuit-closer in complainants' patent, for the reason that when placed in direct connection with the actuating magnet of a signal, it will not close the circuit continuously a sufficient length of time to set the signal in action. The signal machine itself, which forms a part of the apparatus, in the several exhibits of the defendants referred to, and which is shown in Exhibit F, is not a machine of "suitable construction," such as contemplated by complainants' patent, as it is not provided with some suitable means of retaining it in position or action after the circuit, through its actuating magnet, has been interrupted.

It is true that in one sense, a double-circuit instrument and an independent battery may be considered as a means of retaining a

signal in position or action, but the use of this device is excluded by the terms of complainants' specification, in which he states that the object of the invention is to obviate the "inconvenience and expense of employing, as heretofore, one or more separate batteries, situated at or near each signal, for the purpose of actuating the same." Therefore, in putting the invention into practice, I do not consider that a signal machine which should require a special battery, or a constant current of electricity through its magnet to keep it
141 in action, would be a signal of suitable construction within the meaning of the patent, especially as other signal machines, which were of suitable construction, and not open to this objection, were known and in use and described in printed publications prior to date of complainants' patent.

Referring now to the system of the defendant, which is shown in Complainants' Exhibit C, we find the same result produced as that which is produced by the two combinations already described, but the elements of the combination are substantially like those in complainants' patent Exhibit A, and not like those in Defendants' Exhibits A 1, 4, 9, 27, 36, and 41.

It consists of the following elements: First, a track circuit-closer, actuated by a moving train which closes the circuit, not momentarily but continuously, while the train is passing—that is to say, for a period of several seconds; second, an electro-magnet for actuating a visual signal provided with a suitable means for retaining it in position or action, after the circuit through said magnet has been interrupted; and third, a battery for vitalizing said magnet, and which is connected with said magnet and said circuit-closer; these being all elements necessary to set the signal in action.

The following additional elements are employed to discontinue or stop the action of the signal: Fourth, a second track circuit-closer, similar to the first; and, fifth, a second electro-magnet for releasing or reversing the action of the signal which had been started by the first magnet.

In confirmation of my opinion that the elements of the combination in Defendants' Exhibits 1 A, 4, 9, 27, 36 and 41, are not the same elements that are employed in the combination of the defendant, represented by Exhibit C, I will refer to the testimony of defendants' witness, Alvah W. Hall, p. 10, fol. 38, in which, referring to the change of the system of signals on the Eastern railroad so as to operate from one battery instead of many, he says: "My father immediately went to work preparing to alter over the signals which were then in operation on the Eastern railroad and to manufacture an entire new set of track circuit-closers, which became nec-
142 essary in altering the signals on the Eastern railroad." In his answer to cross-int. 82, p. 34, witness refers to these same changes, and says: "In the application of signals as shown in Exhibit No. 10, (the one battery system) it became necessary that the electric circuits which were established through the track circuit-closers, should be established for a longer time than was previously required by the former system of signals. To produce this result a

track circuit-closer, Exhibit E, was invented." This is the track circuit-closer used in the system represented by Exhibit C.

In reference to the alteration in the signal machines, the same witness says, after describing the construction of the old signal machine and of the new or altered one, on p. 35, fols. 135 and 136; the difference in the displaying of these visual signals on the Eastern railroad was, that in the former plan the signal was displayed by a continuous circuit being established through its magnet, and in the latter plan, as shown in Exhibit No. 10, the signal was displayed by the momentary completion of a circuit through its magnet, and the use of the spring catch B of Exhibit G.

Defendants' witness, Geo. H. Snow, describes these same changes in his testimony, commencing on p. 43, fols. 162 to 165, and then says, fol. 170, that after arriving at home about the 20th of January, 1873, "I went to work making these improvements which I have described, drawing, planning, and experimenting; the object of said work, in part, was for the purpose of making such changes as would enable us to work a number of signals with one battery." The same witness, when asked in cross-int. 54, p. 65, if it was practicable to display a signal like that shown at B, in Exhibit 9, for example, by connecting it directly to a track instrument similar to those shown in Exhibit 4, and used on the Harlem railroad, without the intervention of a double circuit instrument, answered that it could not as signal B was constructed.

As the signals in Exhibits 1 A, 4, 27, 36, and 41 are substantially the same, if not identical with that represented at B in Exhibit 9, and as the circuit-closers in all these exhibits are substantially
143 the same, if not identical with that shown in Exhibit 4, it follows that the statement of the witness applies equally to the system represented by each of these exhibits. The same statement is repeated by the same witness at p. 62, fol. 258.

The fact that material alterations were made in the track circuit-closers and signal machines shown in the several exhibits of the defendants above mentioned, further appears from the testimony of defendants' witness, C. H. Mansur, who, at p. 78, fol. 294, says that Mr. Hall, in December, 1872, said to him that he (Hall) was perfectly satisfied that he could work his series of signals, and in a very short time he commenced to make alterations in signal instruments for the purpose of operating a series of signals by one battery. Under Mr. Hall's directions he (Mr. Mansur) commenced to make and put on to the signal what he called a double-circuit instrument or retaining lever, etc. Again, at p. 88, fol. 334, the same witness says, in answer to cross-interrogatory 39, as to whether or not, by the method used before this alteration, two danger and safety signals, such as these originally were, could be worked by one battery, that they could not, as he understood it. Again, at fol. 337, he says: "I understood Mr. Hall that it was necessary to make these changes in order to work a series of signals from one battery." At fol. 341, the same witness explains the difference in the construction and operation of said signals before and after said operation.

The defendants' witness, Thomas S. Hall, at p. 124, fol. 479, speak-

ing of the improvement, which consisted in attaching a locking device directly to the signal, says that it would enable him to operate a larger number of signals placed on both tracks of a railroad by means of one battery. Again, he says, at fol. 491 to 492, that he (Hall) told Hatch that as soon as he could adapt his instruments to the new plan, or one-battery plan, he would apply it between Salem and Lynn, etc. Again, at fol. 495, he says he directed Mr. Snow to assist Mr. Mansur "in making such changes and modifications in our electrical instruments as enable us to operate our system on the one-battery plan."

144 Referring to Defendants' Exhibit 2, this does not differ in the principle of its operation from the other exhibits of the defendant hereinbefore referred to, except that a number of signals placed in the same signal-house are displayed by the action of a corresponding number of circuit-closers through the intervention of a corresponding number of double-circuit instruments, and the primary circuit-closers being actuated by hand instead of by a moving train. Each of these circuit-closers, when depressed, momentarily brings into action a corresponding secondary circuit-closer by means of a primary battery, and this secondary circuit-closer, by means of a secondary battery and secondary circuits, causes the corresponding signal to be displayed. One signal, to wit, an audible signal, is actuated by a secondary circuit taken from the primary battery.

The difference between the several exhibits of the defendant—namely, 1 A, 2, 4, 9, 27, 36, and 41—and complainants' patent, Exhibit A, may be summed up in general terms as follows: Each of the former requires the concurrent action of two distinct batteries to exhibit a visual signal. Each of them, in order to actuate either an audible or a visual signal, requires the concurrent action of two distinct and independent circuit-closers; the first one momentary in its action, and operated by the train or by the signal man; the second dependent upon the action of the first, but differing from it in that its operation is *continuous* instead of *momentary*. In the system shown in complainants' patent the continuous circuit-closer is the circuit-closer directly actuated by the train or the signal man; the momentary circuit-closer is dispensed with, and does not enter into the combination. The primary circuit-closer is connected *directly* with the actuating magnet of the signal; consequently only one battery is required. Furthermore, complainants' patent shows a *series* of signals and a *series* of circuit-closers for displaying and reversing the said signals, arranged at suitable intervals along the line of a railroad, so as to be operated in definite and predetermined succession, which arrangement is essential to the production of the result sought to be accomplished by the invention.

145 Referring to the Defendants' Exhibits 5 and 6, I do not find any circuit-closers of any sort represented in the exhibits, nor do I find any electro-magnets for operating signals.

In Exhibit 10, I find substantially everything in the drawing accompanying complainants' patent, Exhibit A, with the exception that it does not appear, from the drawing, whether the circuit-closers there represented are momentary or continuous in their action.

In connection with what I have already stated, I remark that another change was made in the signal machine, as testified to by defendants' witnesses, for the purpose of better adapting it to be used in combination with the one-battery system. Defendants' witness, G. H. Snow, says, at page 144, fol. 164: "To further decrease the time necessary to hold the circuit closed, the connection between two of the levers on the signal was made in such a manner that a spring formed part of it." After going on to describe the action of the spring, he says, at fol. 165: "Without this spring the circuit would have to be kept closed through the magnet, until the inertia of the signal disc was overcome, and time allowed for its body to move through the required space."

I cite this in confirmation of the statement which I have hereinbefore made, page 116, fol. 460–3, in reference to the operation of Hall's original signal machine, Exhibit F, and which was used in the several applications prior to the time when the several alterations which have been spoken of were made.

Int. 37. Please refer to the testimony of Alvah W. Hall, page 18, defendants' testimony, commencing at fol. 68, and including the answers to ints. 32 to 35, inclusive, and state whether, in your opinion, a person skilled in the art of the application of electricity and electro-magnetism to railroad signalling, would be able, notwithstanding the matters contained in the answers referred to, to construct an apparatus which would accomplish the object which said patent purports to describe, with the aid of the specifications, claims, and drawing, and in the manner therein specified. If you differ from said Hall, please state your reasons therefor.

146 Ans. The witness, Hall, gives six reasons in support of his opinion that the patent would not be sufficient for the purpose named, which I will reply to in their order. First, the proper method of insulating portions of track so as to form circuit-closers was well known at the date of the complainants' patent, having been in public use, and described in printed publications, including prior patents of the complainants'; second, the manner of combining the electro-magnets which actuate or display the respective signals with said signals was also well known, being in public use, described in printed publications, including complainants' patents; third, the mode of retaining the signals in position was also well known; fourth, the phrase, "said signals may be of any suitable construction," taken in connection with the clause in the specification in which the nature and objects of the invention are set forth, necessarily excludes from consideration the employment of a local or secondary battery in connection with the signal, there being signals already known and in use, provided with suitable means of retaining them in action without the necessity of using a local or secondary battery; fifth, the manner of releasing the signals was well known for the same reasons as were given in reply to the second point; sixth, the mode of combining metallic conductors with electro-magnets and circuit-closers is explained in detail in the specification, and illustrated in the annexed drawing.

Referring to the answer to int. 34, it is sufficient to say that the

manner of adjusting the respective resistances was a familiar part of the state of the art, and formed no part of the invention claimed.

In reference to the answer to int. 35, I say that it is not essential, although it is usually more convenient to equalize the resistances of the several circuits.

In confirmation of this I refer to the testimony of complainants' witness, M. G. Farmer, page 15, fols. 58 to 61, complainants' printed evidence.

Int. 38. Please state whether a double-circuit instrument, as you understand the term to be used in this case, is or is not the
147 equivalent of a signal or of two signals; and if not, why not? Before answering please refer to testimony of T. S. Hall, pages 102 and 106, defendants' testimony; also page 144, fols. 390, 408, and 508, and if you differ from the witness give your reasons.

Ans. I consider one machine or device to be the equivalent of another, when it is capable of being substituted for it in an operative combination without changing the result to be obtained.

Although a double-circuit instrument, as shown in Defendants' Exhibits 1 A, 2, 4, 9, 27, 36, and 41, will doubtless perform its functions perfectly when operated by and in combination with the track circuit-closers or hand circuit-closers shown in the same exhibits, yet if a signal-disc were attached *directly* to the armature of either one of the magnets of the double-circuit instruments, as, for example, in Defendants' Exhibits 16 and 17, it would not operate successfully in the combination, because it takes considerable time to overcome the inertia of a signal disc, and to move it through the distance required to cause it to be exhibited; therefore, I consider that a double-circuit instrument is not an equivalent for one or for two signals, in these said exhibits before named.

Int. 39. Defendants' witness, Snow, page 54, defendants' evidence, says complainants' patent does not sufficiently specify a mode of effecting an equality of resistance in the different circuits; defendants' witness, Morton, fol. 689, defendants' testimony, says that the moment such a difficulty should appear it could be overcome by the familiar process there referred to by him; which is right; giving your reasons why you agree with either, or disagree with either or both?

Ans. I think the witness Morton is entirely correct; the method of equalizing resistances to which he refers is, or should be, familiar to all persons skilled in the art of applying electricity to mechanism, and it is of course assumed that a person in charge of the construction of a system of electric railroad signals would understand the use of instruments for measuring and equalizing resistances, in the same way that it would be assumed that an engineer en-
148 trusted with the laying out of a railroad would understand the use of instruments for measuring curves, angles, and distances.

Int. 40. In addition to the exhibits which complainants have put in as showing the state of the art at the date of the patent upon which the bill is brought, state whether or not there is anything in your United States patent No. 130,941, dated August 27, 1872, which in

operating your invention would be useful to one who was familiar with it, as a part of the state of the art at that time, and, if so, will you furnish it to complainants as an exhibit?

Ans. The signal machine described in the patent referred to and described in the specification and illustrated in the annexed drawings, is provided with a device for retaining the signal disc in position or action after the actuating circuit has been interrupted, until released by another current. This device consists in retaining the armature of the magnet actuating the signal by the action of residual magnetism, and is substantially the same as the method used in the signals which I put up near Pittsburg, in August, 1872, as hereinbefore stated. This signal might easily be worked in the combination described in complainants' patent, Exhibit A. I will lay in a copy of this patent.

(Complainants place in evidence the copy referred to, which is marked Complainants' Exhibit E E.)

Int. 41. In your testimony at the foot of page 156 manuscript, page 93, fol. 368, printed evidence, and also at page 216 manuscript, page 116 printed evidence, you say that substantially the same arrangement of circuits as that shown in complainants' patent is now in use, as you are informed and believe, on the Harlem railroad, in New York city. State whether or not you have at any time seen said arrangement in operation on said railroad, and, if so, state when, and describe its operation as seen by you?

Ans. I examined said arrangement or system in June, 1877, in company with Wm. H. Preece, electrician of the British Government telegraphs. A single insulated conductor was attached to
149 one pole of a battery and extended along the line of the railroad; the other pole of the battery was connected with the earth, which thus performed the office of a second conductor. Each signal of the series along the road was operated by a weight and clock-work controlled by an electro-magnet. The circuit-closers consisted of two metallic points which were pressed together by the downward deflection of the rail when passed over by the train. Each of these circuit-closers had one of its contact-points connected with the earth, and the other with the common battery through the signal magnet.

Each signal had two circuit-closers in connection with it, one of which served to exhibit and the other to conceal it. I could not discover that any method of equalizing the resistance of the several circuits was employed. Probably with the particular machines which were used this was not necessary.

Adjourned to February, 25, 1879, 10 a. m.

HARTFORD, *February* 25, 1879.

Adjourned to March 4, 1879, 10 a. m.

HARTFORD, *March* 4, 1879.

Met pursuant to adjournment.

Parties present as heretofore.

It is stipulated that the time for closing the complainants' testimony is extended to March 30, 1879, and that the time for closing the defendants' testimony is also extended to April 15, 1879.

Testimony of F. L. Pope—Continued.

Cross-examined by Mr. BALDWIN:

Cross-int. 42. Did you have before you, in giving the
150 narrative, or autobiographical part of your testimony, a written paper or memorandum to which to refer?

Ans. I did.

Cross-int. 43. Was that paper or memorandum prepared by you for the purpose of this examination?

Ans. It was.

Cross-int. 44. When was it so prepared?

Ans. I prepared it at various times as I had leisure, during the three or four weeks prior to the examination.

Cross-int. 45. Did you observe when you were on the line of the Flushing and North Side railroad of Long Island, in 1870, the appearance and operation of the Hall signals, within their signal-houses, as they were set in action or released by the passage of trains?

Ans. I did not; I only witnessed the action of the signals when riding by on the locomotive or train; I did particularly examine the exterior of one of the track circuit-closers.

Cross-int. 46. Did you not see any visual signals displayed by the passage of a train?

Ans. I did see it so displayed.

Cross-int. 47. Did you not hear some of the Hall audible signals set in action by the passage of the trains?

Ans. My impression is that I did; I cannot say with certainty.

Cross-int. 48. Did you not observe the release of some of these signals after the train had passed?

Ans. I believe I did.

Cross-int. 49. When was the application of electric signals to railroads in such a way as to divide the road into sections, the occupation of which by a train was made to block any approaching train from coming on that section, first known as the "Block Signal System," or the "Automatic Block Signal System?"

Ans. The term "Block Signal System" is of English origin, and has been in familiar use in that country I suppose for twenty-five years; I first heard the term "Automatic Block Signals" applied to Mr. Hall's system on the Harlem railroad to the best of my recollection.

151 Cross-int. 50. Do I understand you by this to mean that the term "Automatic Block Signal System" first came into use in connection with and as describing this application of the Hall signals which you have just mentioned?

Ans. I do not know about that; I say that that was when I first heard it applied.

Cross-int. 51. When was it that, so far as you know, this designation was thus first given?

Ans. My present recollection is that I first saw the term used in an article in a New York daily paper, describing Hall's apparatus, published in the latter part of 1871.

Cross-int. 52. Did you see your apparatus as applied on the Boston and Lowell road, in 1871, after November 20, of that year?

Ans. I saw it again some time in December, and again once afterwards. This last visit must have been in February, the early part, in 1872.

Cross-int. 53. Did you see it in operation in December?

Ans. I did.

Cross-int. 54. How many times, and on how many days?

Ans. I do not now recollect. After my return from Michigan I made a trip to Boston to see that everything was going on right. I think I stayed about two days.

Cross-int. 55. Did you see it in operation in February, 1872?

Ans. I don't recollect positively. This visit was made for the purpose, principally, of consulting the railroad people about continuing the operation of it. I think I saw the signal in operation, but cannot say positively.

Cross-int. 56. Was this particular apparatus ever used by you again after its removal from this road?

Ans. Not in actual service.

Cross-int. 57. Did the Boston and Lowell road make you any compensation for its use while on the road?

Ans. They did not.

Cross-int. 58. Is the use of a lock or detent to keep the visual signal in position after it has been once set, one of the essential elements of the combination covered by your patent, Exhibit A?

152 Ans. It is essential that the signal used in the combination should be so arranged as to remain in position or action after its actuating circuit is interrupted. It is not essential that this result should be effected exclusively by the use of a lock or detent.

Cross-int. 59. Is the use of some device for prolonging or strengthening the effect of the moving train in closing the circuit, so as to keep an electric force in operation long enough to move the signal-disc into position, an essential element in the combination covered by this patent?

Ans. Strictly speaking, I should say not; for if the signal machine, for example, invented by Mr. Hendrickson (Exhibit A A) was used in the combination it would only be necessary to close the circuit long enough to release the escapement, and the signal would then move into position by the action of the weight, whether the circuit continued closed or not. With the signal previously used by us it was necessary to keep the circuit closed until the signal was nearly or quite in position.

Cross-int. 60. Is this machine of Mr. Hendrickson indicated in the specification of your patent Exhibit A as a suitable or possible element in your combination?

Ans. It is not specifically referred to at all.

Cross-int. 61. Is it in any way referred to in that specification?

Ans. Only as it comes within the general description of a signal provided with some suitable means of retaining it in position or action after the circuit is broken.

Cross-int. 62. Was the use of that machine or of some mechanical equivalent to it an essential element in the combination patented in Exhibit A?

Ans. I think it was, if by the word "equivalent" you mean to designate a machine falling within the description in the specification referred to in my last answer.

Cross-int. 63. Which of the claims in this patent describe this element in the combination?

Ans. It is not mentioned in any of the claims in terms.

Cross-int. 64. You say "in terms;" is it in any way mentioned in either of the three claims?

153 Ans. Only in so far as the words "substantially as specified" refer to the kind of signal apparatus mentioned in the specification.

Cross-int. 65. Please quote that part of the specification in which you find this device specified.

Ans. "M, M^1, and M^2 are the electro-magnets which actuate or display the respective signals. Said signals may be of any suitable construction, and should be provided with some suitable means of retaining them in position or action after the circuit through the magnets M, M^1, and M^2 has been interrupted. m, m^1, m^2 are magnets so arranged as to release, reverse, or stop the action of said signals which have previously been brought into action by the magnets m, m^1, and m^2."

Cross-int. 66. Would the use of residual magnetism, by allowing the armature to come in immediate contact with the poles of the main magnet, be a suitable means of itself for retaining the signals mentioned in the specification in position or action after the circuit through the magnets m, m^1, and m^2 was interrupted?

Ans. Yes; I should say it would be.

Cross-int. 66*a*. Would this use of residual magnetism require also the use of any lock or detent for retaining the signal in position or action after the breaking of a circuit?

Ans. It would not.

Cross-int. 67. Were you or were you not correct in your statement in your direct examination, p. 55, fol. 216, that the use of "a signal disc provided with a lock or detent for holding the disc in position after the electric circuit which has brought the signal into position has been interrupted, and an independent magnet for unlocking the said detent and releasing the signal when actuated by an electric current transmitted from the next signal station in the series," was an essential element of the combination in Exhibit A?

Ans. It appears to me that the statement is correct.

Cross-int. 68. Then do I understand you that your combination in that patent could not be successfully used or applied without

154 the use of a lock or detent for holding the signal disc in position after the interruption of the circuit and of an independ-

ent magnet for subsequently unlocking the detent, as specified in your answer, fol. 216?

Ans. I understand the word detent to mean any device which detains the disc in position, whether mechanical or magnetic. Some device for that purpose is essential, and so, also, is the independent magnet for releasing or reversing the signal by unlocking or letting loose the detent or withdrawing the signal from its action.

Cross-int. 69. Do you attribute the same meaning to the word lock which you have just attributed to the word detent?

Ans. As there used I think it means substantially the same thing.

Cross-int. 70. Were the two parts of Defendants' Exhibit 1 (defendant's evidence, pp. 214 to 230) read by you as one paper at the same meeting of the New York Society of Practical Engineering, March, 13, 1872?

Ans. They were.

Cross-int. 71. Were the complainants paid any compensation for the application of their apparatus on the Philadelphia & Erie R. R.?

Ans. They were.

Cross-int. 72. How much?

Ans. I do not know. They were paid the price agreed upon, but I do not now recollect the amount, as this was not my special part of the business.

Cross-int. 73. Was this payment sufficient to meet the cost of putting up and supplying the apparatus?

Ans. I cannot say; I had nothing to do with keeping the books.

Cross-int. 74. Is that apparatus now up on that road?

Ans. I do not know; it was the last time I was there.

Cross-int. 75. When was this?

Ans. Early in the spring of 1874.

Cross-int. 76. Were they then in actual use for the purposes of the road?

Ans. I believe they were.

Cross-int. 77. Do you know whether they were then working in such a way as to be reliable as practical signals?

155 Ans. I cannot say. There were several occasions when these signals worked unsatisfactorily, for reasons given in my direct examination, but as by the agreement they were not to be paid for until they were in satisfactory working order, and they were not paid for until they had been in use some months, I assume that their working at that time was satisfactory to the railroad company.

(Defendants' counsel object to the last part of the answer, as argumentative and not responsive.)

Cross-int. 78. Were you ever able to detect, otherwise than by attributing the trouble to the geological formation at that place, the cause why your track-sections proved to be imperfectly insulated, thereby preventing the proper operation of the apparatus?

Ans. There were no track-sections or track circuit-closers connected with these Philadelphia and Erie signals. They were worked by hand circuit-closers, and were not automatically operated by the trains.

Cross-int. 79. I will ask, then, whether you were ever able to detect, otherwise than by attributing it to the geological formation, the reason why your apparatus, as put up at Sunbury on that road, did not at all times work properly?

Ans. Interruptions sometimes arose from other causes, which were readily detected by a competent telegraph repair man. Two causes I particularly recollect: One was the failure of a battery, owing to the connection of the wire with the copper plate being eaten off, which occurred quite frequently in the particular kind of battery used, and which was not a good form; the other was a contact of the signal wires with the telegraph wires, caused by the workmen who were rebuilding the bridge across the Susquehanna, over which the wires ran.

Cross-int. 80. Did not this apparatus sometimes fail to work properly, when you could assign no other reason for it than the geological formation at the place?

Ans. Such was the case in several instances. The nature
156 of the difficulty was easily determined to be an abnormal and variable resistance in the earth circuit, of the true cause of which I have never been able to fully satisfy myself.

Cross-int. 81. Do you attribute it to this cause because, after investigation, you were unable to discover any other?

Ans. Yes; I think I may say that is the fact.

Cross-int. 82. Is your application made on the Pennsylvania railroad still in actual use by that road for railroad purposes?

Ans. If you refer to the application made in 1872, it is not.

Cross-int. 83. When was it removed or disused?

Ans. In the latter part of 1872; I cannot give the exact date; Mr. Hendrickson had charge of the removal.

Cross-int. 84. Did the Pennsylvania Railroad Company pay the complainants anything more than half the expense of making the application, so far as you know?

Ans. I believe not; they paid the actual cost of materials used, which were not returned, and for all the labor other than that of myself and Mr. Hendrickson, but nothing more.

Cross-int. 85. Why did you dispense with the mechanical lock or detent, and the independent unlocking magnet, in your application on this road?

Ans. In order to simplify the machinery as much as possible; dispensing with it also reduced the cost of the machine considerably.

Cross-int. 86. Did the result prove that such a use of magnetic force or residual magnetism was not an efficient substitute in actual practice on a railroad for a mechanical detent?

Ans. As used in this application, it proved to be objectionable; in the modification subsequently adopted by us its action was entirely efficient and satisfactory.

Cross-int. 87. When and where was this subsequent application, as modified?

Ans. The first machine so modified was completed in the latter
part of November, 1872; we afterwards used it at Pittsburgh,
157 Bethlehem, Bear Creek, Baltimore, and Greensburgh; the

application at Greensburgh was made in the latter part of 1873, and the same machines have been in use there from that time to this.

Cross-int. 88. When did you last see the apparatus set up by you on the Lehigh Valley railroad?

Ans. I can say that it was in the latter part of 1873.

Cross-int. 89. Did you then see it in actual operation by railroad trains?

Ans. I did.

Cross-int. 90. On what part of the road?

Ans. At Bear Creek.

Cross-int. 91. Did you ever yourself, in behalf of the complainants, receive any payment on behalf of the Lehigh Valley railroad for this application?

Ans. I did not.

Cross-int. 92. In fixing the date of your first conversation with Mr. Hendrickson in regard to the one-battery system as having been prior to November 6, 1872, is your recollection guided in part by the dates and entries in his pocket memorandum book, which is in evidence?

Ans. Not at all. I never saw the inside of the book until it was put in evidence.

Cross-int. 93. Did you hear his evidence on this point and see the entries in the book before giving your own evidence as to this date?

Ans. I did.

Cross-int. 94. Have you any entry or memorandum of such a conversation with Mr. Hendrickson and of this date, made by yourself at or about such date?

Ans. I have not.

Cross-int. 95. Had you conversed with Mr. Hendrickson before he gave his testimony as to the place and date of that conversation as to the one-battery system in regard to such conversation and the place and time of the same?

Ans. We did have some such conversation.

Cross-int. 96. How are you able to fix February 10, 1873, as the date of your conversation with Mr. Davis?

158 Ans. I did not fix it on February 10, but between the 30th of January and the 10th of February. I fix the date of my return home from my Western trip by the telegram which I sent Mr. Ashley from Gallipolis, Ohio, and I stayed over the following Sunday at Marietta, Ohio, and came directly home from there. The date of the 10th of February was when I went from home to Sunbury, and the fact that I remained there for some weeks I fix by letters written by me while at Sunbury and Northumberland; and I recollect that being prevented by illness from stopping to see Mr. Davis on my way home from the West, as I had telegraphed Mr. Ashley I would do, that I did go to Baltimore to see him within a very few days thereafter.

Cross-int. 97. In what place in Baltimore did this conversation between you and Mr. Davis take place?

Ans. At the Camden station of the Baltimore and Ohio Railroad.

Cross-int. 98. Did you describe to him the particular nature of your plan for working a number of signals from one battery so as to let him know how the apparatus might be constructed?

Ans. I do not recollect how far I went into details in this description; I do not think that I made any sketch, and it is my impression that I described it only so far as was necessary to convince him that I could do what I claimed.

Cross-int. 99. Did you subsequently make an application of your one-battery system on the Baltimore and Ohio road?

Ans. I did not, further than to put up one signal, which was done for the purpose of illustrating the action of the signal apparatus itself. I should, perhaps, say that the actual work of putting up this signal was done entirely by Mr. Hendrickson; I merely inspected it after it was done and in operation to see that it was according to the plans.

Cross-int. 100. Did the signal in any way illustrate your one-battery system?

Ans. It illustrated the operation of one signal in that system, but not that of two or more from one battery.

Cross-int. 101. Was it anything more than one of your old signals set up just as those signals had been set up prior to your invention or conception of the one-battery system?

159 Ans. The only difference was that the signal magnet was connected directly with the track circuit-closer. Prior to this we had usually employed a relay and secondary battery for this purpose.

Cross-int. 102. Had you not, in several instances prior to your thinking of the one-battery system, connected your signal magnets directly with your circuit-closers?

Ans. Not with the track circuit-closer. We did it with the hand circuit-closer at Boston.

Cross-int. 103. Had this direct connection of signal-magnet with track circuit-closer any necessary connection with the one-battery system?

Ans. Yes; it had.

Cross-int. 104. Please explain what you mean.

Ans. When the relay is used it necessitates the employment of two separate batteries, or from two to four circuits simultaneously closed from one battery, and this division of the current is objectionable in a one-battery system, because the battery has to be made powerful enough to supply all these circuits at once, which in practice would be a very difficult matter.

Cross-int. 105. Was not your object in omitting the relay in putting up this signal to show in its simplest form on a short circuit the operation of one of your signals by a passing train?

Ans. That was the object.

Cross-int. 106. And was it any part of your object to illustrate by the signal how you could construct a one-battery system for several signals?

Ans. In a certain sense it was. After explaining the one-battery system to Mr. Davis, either he or some other one of the officials re-

quested us to put up one signal as a sample of the system, and this signal was put up in compliance with that request.

Cross-int. 107. Were you requested to put up this signal as a sample of your general system which had already been tested by use, or as a sample of your new and untried one-battery system?

160 Ans. That I cannot say positively. I had previously been told by Mr. Davis that the multiple battery system would not answer for their road.

Cross-int. 108. When was this signal set up?

Ans. I think it was in March, 1873. I had nothing personally to do with putting it up.

Cross-int. 109. Did you ever apply to any officer or agent of the Harlem railroad while Mr. Edwin D. McCracken was negotiating with you to ascertain if he was employed by that company, or how his negotiations in your behalf were progressing?

Ans. I never did.

Cross-int. 110. Does Exhibit C C (diagram and explanation) show the nature and operation of your one-battery system in such a way as to make it plain and intelligible to a person skilled in the art of mechanical electricity?

Ans. It does not, if you mean to enable him to construct the apparatus or understand the details of it.

Cross-int. 111. Since March, 1875, have you devoted any considerable portion of your time or attention to the subject of electric railroad signals, except in connection with the preparation of this case?

Ans. I have not, further than to act as consulting electrician, if I may so call it, when needed.

Cross-int. 112. How much of your time has been occupied in advising as such consulting electrician?

Ans. A comparatively small portion of it. I cannot say exactly how much.

Cross-int. 113. Had you an office on Broadway in the winter of 1869 or the spring of 1870?

Ans. In the winter of 1869 my office was on New street, in a building running through from Broadway to New street. In the spring of 1870—I think the 1st of May—I moved into the Broadway end of the same or adjoining building.

Cross-int. 114. Did the Illinois Central, the Chicago and Northwestern, or the Milwaukee and St. Paul railroad pay your firm for your signal applications, so far as you know, enough to cover the cost of supplying and putting up your apparatus?

161 Ans. I have no means of knowing without reference to the books.

Cross-int. 115. When did you first construct and put to the test of actual experiment an apparatus for actuating several signals by one and the same battery in the manner which we have termed the one-battery system?

Ans. I have never actually constructed and put in operation such a system further than I have stated in my direct evidence, page 63, folios 249 and 250, which was in October, 1872. I speak of the sys-

tem as a whole. The several parts of it had, most, or all of them, been tested in practice before my application for a patent was made.

Cross-int. 116. When, if ever, did you first construct and put in practical operation an apparatus such as is described in your patent Exhibit A?

Ans. I have never constructed and put in practical operation on a railroad the combination described in that patent.

Cross-int. 117. Have you ever constructed and put in operation such an apparatus elsewhere than on a railroad?

Ans. I constructed a working model of the whole apparatus, including the railroad and train in miniature, three or four years ago, for the purpose of exhibiting and illustrating its practical operation, and this was so arranged that full-sized signals could be, and actually were, operated as a part of the combination.

Cross-int. 118. Where was that exhibited?

Ans. It was set up in our shop in Centre street, New York. I think we also had it at the office in Vesey street at one time, but am not certain about that.

Cross-int. 119. Is the combination described in your testimony on page 63, folios 249, 250, 251, identical with the combination covered by your patent Exhibit A.

Ans. It is not.

Cross-int. 120. Is any provision shown in Exhibit X, Exhibit Y, or Exhibit Z for equalizing the resistances of the several circuits in your one-battery plan?

Ans. In Exhibit Y two subsidiary circuits of different lengths are shown in connection with one battery and two circuit-closers,
162 one circuit-closer for displaying and the other for reversing the signal; these two subsidiary circuits, one of which is a short circuit and the other presumably two miles in length—a mile out and a mile back—are each marked "20 ohms," meaning units of electrical resistance. As this is not far from the actual resistance of a two-mile circuit of ordinary telegraph wire, the inscription I suppose to be intended to indicate that the two circuits were to be made of equal resistance; with that exception, there appears to be no indication of any equalization of circuits in the exhibits mentioned.

Cross-int. 121. Does what you term an exception in Exhibit Y indicate the mode of equalizing the resistances?

Ans. I don't think that it does.

Cross-int. 122. Could the plan of the one battery system be applied successfully in practice without some mode of equalizing the resistances of the several circuits?

Ans. In my opinion it could, if a signal machine of a character similar to that of Hendrickson Exhibit A A, or probably with almost any signal on a short section of a mile or two. As the length of the system is increased it becomes more important to equalize the circuits.

Cross-int. 123. Was the machine of Hendrickson to which you refer invented at the date you assign to Exhibit Y?

Ans. I presume it was, for the reason that an outline of it appears

in the sketch Exhibit Y. I don't think I ever knew anything about this invention until Exhibit Z was shown me on December 3, 1872.

Cross-int. 124. At the time of your conversation with Mr. Hendrickson, which led to his drawing Exhibit Y in his pocket-book, were you acquainted with any machine such as is represented by Exhibit A A?

Ans. I was not.

Cross-int. 125. Then did you at that time have any knowledge of such a mode of equalizing resistances as is afforded by that or any similar machine?

Ans. I don't understand that the machine referred to has anything to do with the equalizing of resistances. It can be
163 worked without such equalization over a considerable length of road, for the reason that the battery power required to operate the most distant signal is comparatively small, and not sufficient to injure the circuit-closer or magnet which is close to the battery.

Cross-int. 126. Would the apparatus indicated by Exhibit Y work successfully on a long circuit, say of 5 or 10 miles, without the introduction of some mode of equalizing resistances?

Ans. I have no doubt that it would.

Cross-int. 127. Will the combination described in your patent, Exhibit A, work successfully on such a circuit without the use of some mode for equalizing resistances?

Ans. I think not, if signals operated wholly by the power of the battery were used. With signals like Exhibit A A, or on that principle, I think it might be operated with perfect success, but would be less economical in its operation, because of the exertion of an unnecessary amount of force in the shorter circuits, which involves a corresponding unnecessary consumption of battery material.

Cross-int. 128. Is your answer to cross-int. 126 predicated on the assumption that the upper part of Exhibit Y, on the right-hand leaf of the pocket-book, is a sketch of what afterwards took the shape of Exhibit A A?

Ans. It is.

Cross-int. 129. Does Exhibit Y show how or where the sketch last mentioned is to be attached to the lower part of the exhibit?

Ans. The upper part of Exhibit Y appears to me to be a sketch, somewhat more in detail, of the left-hand signal and its connections in the sketch forming the lower part of the exhibit; that is my understanding of it.

Cross-int. 130. In Exhibit, Bianchi No. 42, you say, on folio 386, that the plan differs from that in Exhibit A, among other things, in this, that the signals are merely small dials, or indicators, not capable of attracting the attention of an engine-driver. Is there any difference, in principle, as respects this patent, in actuating a small signal or a large one, provided the same means for actuating them are employed?

164 Ans. Not if the same indications are shown.

Cross-int. 131. Does it constitute any difference in principle

whether the signal is displayed in the office of the station-master or outside and in sight of the engine-driver?

Ans. I should think not.

Cross-int. 132. If the earth is made part of the circuit, is not the expense of repairing and maintaining that part of the circuit reduced to the minimum, in comparison with the cost of repairing and maintaining a wire conductor of the same length?

Ans. It ordinarily is. I did not find it so at Sunbury, however.

Cross-int. 133. Referring to your testimony on folio 447, when did the arrangement of sounders therein described first begin to be superseded by other arrangements?

Ans. I cannot say exactly. It has not been much used, in fact not at all to my knowledge, since about 1869 or 1870. I have been told it was still used in San Francisco within a year or two.

Cross-int. 134. What was the difficulty which led to the abandonment of this arrangement?

Ans. The difficulty referred to in paragraph 85, page 55, of my book. (It is agreed that the book may be referred to by either party on the hearing.)

Cross-int. 135. On folio 453 of your testimony you say that you have really or never measured the resistance of the earth when it was less than 30 units. What was the surface of the earth plate in use at the point where these measurements were taken?

Ans. Probably not to exceed fifteen or twenty square feet.

Cross-int. 136. If a galvanic battery has one of its poles connected to the earth, would you consider it correct to say that the earth was virtually a prolongation of that pole of the battery?

Ans. I think it would be correct to express the fact in that way.

Cross-int. 137. Is the potential or tension of the earth properly zero; or, in other words, the starting point from which the tension of bodies charged with electricity is measured, just as we measure heights from the level of the sea?

165

Ans. Yes; the earth is assumed to be the zero of potential when no other is mentioned, just as we assume longitude to be reckoned from Greenwich, unless Washington or Paris or some other place is specified.

Cross-int. 138. Is not the earth a reservoir of electricity, so far measureless, practically, that any amount of electricity from a battery may be thrown into it, or removed from it, without affecting its tension?

Ans. That is true, in the same sense that it is true that the earth is not attracted perceptibly by a falling body which is attracted towards its surface.

Cross-int. 139. The tension of the earth being zero, would a conductor, by being connected with it, acquire any tension, either positive or negative?

Ans. It would, but the tension would be almost infinitely small.

Cross-int. 140. Would not such a conductor, for all practical purposes, be considered as neutral, and equally ready to receive either positive or negative electricity, if brought to it?

Ans. It would, and the same would be true of any other conductor occupying the same relative position in a system of circuits.

Cross-int. 141. If one pole of a battery were connected with the earth, would you say that all metallic conductors connected with the earth were virtually prolongations of this pole of that battery?

Ans. Considered with reference to that battery, they would be.

Cross-int. 142. If two batteries had one pole each connected with the earth, in one the positive pole and in the other the negative pole, would you say the earth was virtually a prolongation of each of these poles?

Ans. I should say that it was.

Cross-int. 143. Which of the conductors, C or Z, in the dia-
166 gram accompanying your patent, Exhibit A, would be earth, if considered as virtually a prolongation of the pole of the battery, most resemble?

Ans. I do not see that it would resemble one more than the other. It might be substituted for either.

Cross-int. 144. If two insulated wires are connected with the positive and negative poles of a battery, respectively, will not one acquire a positive and the other a negative charge or tension?

Ans. In reference to each other, yes.

Cross-int. 145. If these wires are each then connected with the earth at their outer ends, will not the first or positive conductor have a positive tension greatest at the point nearest the battery, and decreasing to nothing at the other end, which is connected with the earth, while the wire connected with the negative pole has in like manner a negative tension greatest at the battery and zero, at its end connected with the earth?

Ans. Yes; your question properly describes the condition of the wire under these circumstances.

Cross-int. 146. In the operation of the track circuit-closers, at the Centennial, where the track was under water, do you know the resistance, as expressed in electrical units, to the passage of the current from one track to the other under water?

Ans. I do not; I never had the opportunity to make a measurement under these circumstances.

Cross-int. 147. Supposing the same battery cells in each case, how many would be used on a single telegraph line five hundred miles long, and how many on an electric signal line of ten miles?

Ans. A telegraph line five hundred miles long ordinarily employs about two hundred and fifty cells; a signal line ten miles long would probably require from fifty to one hundred cells, according to the force required to operate the particular kind of signals used, but in this case it would be economical to use cells of a larger size and less in number.

Cross-int. 148. If we used cells of the same size on each line, what would be the amount of current flowing in each case, assum-
167 ing the wires all to be alike and no leakage to occur, and the cells to be the same number indicated by you?

Ans. If we assume the strength of the current in ten miles of wire with one hundred cells as unity, or one with fifty cells, it

would be $\frac{1}{2}$ that, and with five hundred miles of wire and two hundred and fifty cells of battery, it would be $\frac{5}{1000}$, or $\frac{1}{200}$ of unity. In practice, it would not be much over half this strength in a telegraph line, because of the number of instruments inserted in the circuit, whose combined resistance is nearly as much as that of the line, so that probably $\frac{1}{400}$ would be not far out of the way.

Cross-int. 149. On page 46 of your book, do you say that the earth offers, practically, no resistance when it is made part of an electric circuit?

Ans. I do.

Cross-int. 150. Is that a correct statement in the form in which it is there given?

Ans. I believe it to be such.

Cross-int. 151. Do you state on pp. 59 and 91 of your book that hard rubber, when used as an insulator, soon loses its property of repelling moisture if exposed to atmospheric influences?

Ans. Yes; that is what is substantially stated therein.

Cross-int. 152. Do you state on same page and 92 that glass insulators are generally made concave at the bottom, which prevents the current from escaping during a rain to the wet bracket and pole through the medium of a continuous stream of water?

Ans. Yes; that is the tenor of my statement.

Cross-int. 153. On p. 91 and 142 do you state that the edge of a glass insulator must never be permitted to touch the shoulder of the bracket, for in this case, during a shower, a continuous stream of water flows directly from the wire to the pole, entirely destroying the usefulness of the insulator?

Ans. I do.

Cross-int. 154. Are these several statements in your book, referred to in the foregoing questions, correct in the form in which they are therein expressed?

168 Ans. They are, with the exception of the last sentence of the last statement, which is, perhaps, a little stronger than the facts would warrant; an insulator which touched the shoulder of a bracket would be some better than no insulator at all, though not very much, from a telegraphic point of view.

Cross-int. 155. Have you printed a second edition of this book; and, if so, when?

Ans. A considerable number of editions, so called, have been printed, but no change has been made in it since 1870 or 1871, when a number of pages were added to the last part of it.

Cross-int. 156. Have you in any edition modified the statement which in your last answer but one you say is not quite correct?

Ans. I think not.

Cross-int. 157. Is De Castro's book on L'Electricite et les Chemins de Fer, Paris, 1859, two volumes, a standard authority on that subject?

Ans. I do not know; I am not familiar with the book, although I have seen it, and the impression it made on me was that it was mainly a compilation from publications already existing.

Cross-int. 158. Are you acquainted with the following works:

Du Moncel's Traité Théorique et Pratique de Téelégraphie Electrique, Paris, 1864, and A. de la Rive's Tratié d'Electricité, Paris, 1858, three volumes?

Ans. I am quite familiar with them.

Cross-int. 159. Are they standard works of authority among electricians?

Ans. They are regarded as such.

Cross-int. 160. Is the same true of Ferguson's work on electricity, published in London in 1866?

Ans. In my judgment, it is.

Adjourned to March 5, 1870, 10 a. m.

169 HARTFORD, CONN., *March* 5, 1879.

Met pursuant to adjournment.

Testimony of F. L. Pope—Continued.

It is stipulated that the testimony of the parties yet to be taken may be taken before the examiner in this case, or any examiner who may be agreed upon by the parties, in any other district, and that this stipulation shall apply to all testimony hereinbefore taken.

Redirect int. 162. You say, in answer to cross-int. 92, that you had means of fixing the date of the conversation with Hendrickson other than his memoranda; will you please state what those means were?

Ans. I filed my application for patent No. 140,790 on the 24th of October, 1872, as the patent itself shows; I was in Washington myself on that day, and handed the application to the chief clerk; I went immediately from there to Sunbury by the Northern Central R. R.; Hendrickson and I finished the work at Sunbury at that time, on the day of the presidential election, which was the 5th of November, if I recollect right. The next morning we went to Bethlehem, and on arriving got New York papers containing the result of the election; this conversation with Hendrickson took place between those dates—that is to say, between the 25th day of October and the 6th day of November, 1872; I don't think I had seen him before that, after he left me at Pittsburgh in August.

Redirect int. 163. State whether or not you personally recollect where the conversation was, with reference to its being in some building or out of doors, and if in some building, what building?

Ans. I do; in removing a portion of the signal apparatus, I believe in the forenoon of the first day that Hendrickson was there,
170 we broke one or more of the connecting wires of the magnets, and at noon took the apparatus to a jeweler's shop in Northumberland to have him (the jeweler) resolder the connections; it was while we were waiting in the jeweler's shop to have this done that the conversation took place; and we also talked about it aa we went from the shop to the hotel for dinner.

Redirect-int. 164. Have you the telegram which you state, in answer to cross-int. 96, you sent to Ashley from Gallipolis; and, if so, will you annex it as an exhibit to your testimony?

Ans. I have, and here produce it. (Telegram placed in evidence, and marked Complainants' Exhibit F F.

Redirect-int. 165. You stated yesterday, in your cross-examination, that the sketch that you gave to McCracken would not enable one familiar with the art to construct the apparatus; will you please state what it did show.

Ans. It was intended to show how many wires and batteries were required by my system to produce the result, but the details of the apparatus were purposely omitted.

Recross-int. 166. Is the Exhibit F F the original dispatch signed and sent by you?

Ans. It is not.

Recross int. 167. When did you first see Exhibit F F?

Ans. About a month ago.

FRANK L. POPE.

Subscribed and sworn to before me, this 5th day of March, A. D. 1879.

E. E. MARVIN, *Examiner.*

171 U. S. Circuit Court, District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL COMPANY
v.
THE HALL RAILWAY SIGNAL COMPANY.

Deposition of Moses G. Farmer,

On the part of the complainants, taken before R. E. Stilwell, examiner, to be used on the final hearing of this cause.

NEW YORK, THURSDAY, *March* 13, 1879.

Present: Frank L. Pope, complainant, in person, John Van Santvoored, counsel for defendant.

MOSES G. FARMER, called on the part of the complainants:

Q. 1. Please state whether or not you have personally had any practical experience in the construction and operation of electric magnetic machinery; and, if so, when, for how long a time, and in what department?

A. I have, since the year 1845; I have constructed electro-magnetic clocks, electric locks, electric chronographs, printing telegraphs, fire-alarm telegraphs, electro-magnetic engines, magneto-electric machines, electric torpedo apparatus, electric light apparatus, electro-magnetic signal apparatus for railroads, and very many other electro-magnetic devices.

Q. 2. Have you ever had any practical experience in connection with the construction, maintenance, and management of telegraph lines?

172 A. I have; I have built one or two short lines of telegraph; have put in operation some two or three hundred miles of telegraph line; was superintendent of the Vermont and Boston telegraph lines in the years 1850 and 1851, and in 1868 or 1869 was

employed by the New York, Newfoundland and London Telegraph Company to examine and report upon the condition of their lines on Cape Breton and Newfoundland.

Q. 3. In your former testimony, page 11, from folios 40 to 47 of complainants' evidence, you say that you have examined the patent, Complainants' Exhibit A, and think that you understand the scope of the invention. Please state whether or not, in your opinion, the specification and drawing of said patent give such a description of the invention which it purports to set forth, that a person "skilled in the art of the application of electricity and electro-magnetism to railroad signalling" would be able from said patent, specification, and drawings, and without other aid, to construct an apparatus which would accomplish the object which said patent purports to describe. Before answering, please refer to the evidence of A. W. Hall, defendants' evidence, page 18, fols. 68 to 72; G. H. Snow, page 54, fols. 204 to 206; T. S. Hall, pages 135 and 136; and Henry Morton, pages 155 to 158, and 187 and 188, and if you differ in opinion from those witnesses, please give your reasons for such difference of opinion.

A. The simple problem seems to be this: With a single battery, having conductors extended from each of its poles along the line of a railroad, and having a number of signal stations, with their appropriate circuit-closers, to display these signals in succession automatically by the motion of the train as it passes along the road, displaying each signal as it is approached, and releasing the signal when it is no longer needed. Considering the state of the art at the date of the patent, looking at Johnson's signal, patented in 1858, realizing, too, that the laws of electro-magnetism were, at the date of Mr. Pope's patent, well understood by those skilled in the art, and the means well known for equalizing the resist-
173 ances in branch circuits, and for determining beforehand the proper construction of electro-magnets for the purpose of displaying these signals, as well as for the purpose of releasing them, I should not hesitate to say that the patent gave ample instructions to persons skilled in the art to accomplish the objects set forth, without any other aid than the common stock of knowledge which he ought to possess, and the instructions given in the Pope patent, referred to.

Q. 4. Have you examined Defendants' Exhibits, 1 A, 2, 4, 5, 6, 9, 15, 34, 35 and 36, and have you read the testimony of defendants' witness, Morton, in reference to said exhibits, especially those contained in folios 676 to 683 of defendants' printed evidence?

A. I have examined those exhibits and read the evidence of Professor Morton in this case.

Q. 5. Please say whether, in your opinion, the several arrangements or combinations of elements described in the specification, and claimed in the several claims of complainants' patent, Exhibit A, taking into consideration the state of the art at the date of said patent, especially as shown in the several exhibits referred to in the last question, constitute a patentable invention, as distinguished from a mere mechanical arrangement or aggregation of well-known devices which a person skilled in the art might have constructed or put together without the exercise of invention. In answering,

please refer to the answer of defendants' witness, Morton, to interrogatory 26, page 180, defendants' evidence, and if you differ from him in your opinion, please give your reasons.

(Counsel for defendants objects to the question as irrelevant, also as indefinite, and as asking the witness to give a construction of the claims.)

(Question amended by substituting for the words "constitute a patentable," the words "involve the exercise of.")

A. As I understand it, the object to be accomplished by the patent is very simple, which is to operate a series of signals by the
174 passage of a train, making use of a single battery. Now, I take it that it involves the exercise of the inventive faculty to select a suitable combination of well-know devices for the accomplishment of this purpose, and in none of the exhibits referred to do I find such a combination of well-known devices as would accomplish the object desired. In one of the exhibits, if I recollect right, is a series of circuit-closers, and I think a series of signals, but not such an arrangement and combination of devices as would operate these signals successively by the successive action of these circuit-closers operating upon one and the same battery; and as Mr. Pope's arrangement does accomplish the desired object by a combination of devices which I do not find prior to his patent, I consider that his production was a true and legitimate exercise of the inventive faculty as distinguished from the act of aggregating a collection of well-known devices.

Q. 6. In your former testimony, pages 17 and 18 of complainants' evidence, folios 66 to 69, you state in substance that the equalization of the resistances of the several subsidiary circuits shown in Exhibit C was due to the arrangement of the wires, and not to the use of the earth as a conductor; please say whether, in your opinion, the use of the earth in Exhibit C, as distinguished from the arrangement shown in Exhibit Q, would constitute a material change, involving the exercise of invention, and give your reasons for such opinion as you may express.

A. It would not. It would be merely a substitution in the combination of one well known equivalent for another. In some cases practical skill and judgment would suggest the use of one device in preference to the other. Especially in such cases where the earth is a very poor conductor, and variable with the state of the atmosphere and of the soil. In such cases the metallic conductor would be better than the earth conductor.

Q. 7. In your former evidence, pages 15, 17, and 18, you say to equalize the resistances of the several circuits extending for any considerable distance along the railroad, relying only upon the device of varying the size of the metallic conductors,
175 would present no practical difficulty to a competent electrician. Please refer to the evidence of A. W. Hall, defendants' evidence, pages 10 and 11, and G. H. Snow, pages 50 to 53, and also page 70, cross-interrogatory 76, describing their experiments for several months, and their inability to arrive at a successful

result, until February 14, 1874, and say whether or not a knowledge of the specification of the patent, Complainants' Exhibit A, would have enabled a competent workman, skilled in the art, to have accomplished the desired result without any necessity of making a series of experiments such as described by these witnesses, and give your reasons for any opinion you may express.

A. I think that the knowledge which should be possessed by a competent person, skilled in the art, taken in connection with the instructions contained in Mr. Pope's patent, should enable such person to decide beforehand upon the amount and arrangement of the necessary battery, the size and construction of the electro-magnets, and the dimensions of the conductors to be used, so as to effectually prevent the burning and destruction of the circuit-closers, referred to, without making the tedious and long protracted experiments referred to. I think that that necessary knowledge could be obtained from books printed before the obtaining of this patent.

Q. 7. Please examine the diagram on page 55 of Mr. Pope's book, Complainants' Exhibit R, and state what you understand therefrom to be the object of the peculiar arrangement of circuits therein shown, and state also whether you have any knowledge of such a device as is there shown having been in public use prior to the date of complainants' patent, Exhibit A.

A. The object of the device appears to be to equalize or regulate the effect of the battery E upon the electro-magnets of the various sounders, 1, 2, 3, and 4, by causing the resistances of those several branches to be equal to each other if the electro-magnets are all similar, and I remember to have seen such a system of operation in use in Boston in the Western Union office, to the best of my recollection, several years prior to complainants' patent, Exhibit

176 A. It was used in the office of the Western Union Company as a means of working all their sounders from one local battery, those sounders being distributed in different parts of the building, and at different distances from the battery, at such different distances as made it at least desirable to equalize the resistances of these respective circuits.

Q. 8. State whether, in your opinion, the method by which the equalization of the currents traversing the several subsidiary circuits is effected in the arrangement represented by Exhibit R is or is not the same as the method by which the same result is effected in the arrangement represented by Complainants' Exhibits C and Q and Defendants' Exhibits 8, 14, and 40?

A. In my opinion it is substantially the same.

Q. 9. Please read the evidence of complainants' witness, F. L. Pope, page 68, folios 269 and 270, and also page 135, folios 537 and 538, in which he describes a difficulty experienced by him in operating railway signals through an electric circuit composed in part of the earth, and state whether you have any knowledge of other instances of the same kind, and if so, where.

A. I have frequently met with similar difficulties, one of which was on the White Mountains, where the resistance of an earth contact, the best that could be found at that place, was equal to more

than six hundred miles of ordinary telegraph wire. In such a case it would be manifestly unadvisable to use the earth as a part of the circuit, because so much battery would be required. I met with a similar instance in Newfoundland. I have met other instances when, in some conditions of the soil, the resistance of an earth circuit would be from three to five times as great in dry weather as in wet. I have met with instances in Cape Breton, where what is known as earth currents or auroral currents would produce an effect greater than would be produced by twenty cells of Daniels' battery in the same circuit. I remember also an instance in Boston, some ten or twelve years since, when the influence of an auroral current was greater than sixty of that of Daniels' cells on the same
177 circuit and which current was constantly varying in direction, and were this to happen on a railroad signal line, using the earth as part of a circuit, it would confuse or disarrange the operation of the signals more than would happen in a case where an entire metallic circuit was used which was properly insulated from the earth.

Q. 10. Would not a system of electric railroad signals having its electric conductor sformed partially of an earth circuit, be much more liable to an interruption or a disarrangement from electrical discharges during thunder-storms than a similar system in which the conductors were insulated from the earth?

A. It would, because of the more ready tendency of the electric discharges to find a path to the earth.

Q. 11. In view of what you have stated in your answers to the last two questions, would it in all cases be practicable, economical, or safe to rely upon the earth as a return conductor in a system of automatic railroad signals such as that shown in Complainants' Exhibit C and Defendants' Exhibit 14?

A. I should not consider it practicable in rocky tunnels, economical on the White Mountains, or safe where the resistance of an earth circuit varies very greatly with the condition of the soil.

Q. 12. Look at the sketch which I now hand you, marked Complainants' Exhibit X, and state in detail whether or not it clearly shows each and all of the material features of the combinations described in the complainants' patent, Exhibit A, and claimed in the several claims thereof.

A. I find that it shows the equivalent of the battery B, a positive and negative conductor, C and Z, to electro-magnets actuating, or causing to be actuated, visible or audible signals, and two or more circuit-closers placed at intervals along the line of the railroad. I find also the combination of the battery B, conductors C and Z, circuit-closer A, and electro-magnet for actuating a visible or audible signal with a circuit-closer, wires, and electro-magnet for reversing, releasing, or stopping said signal.

Q. 13. Please make the same comparison between the diagram, Complainants' Exhibit Y, and the patent, Complainants' Exhibit A.

178 A. In Exhibit Y I find what is represented to be equivalents to battery B, in combination with positive and negative con-

ductors C and Z, two or more electro-magnets for actuating visible or audible signals placed at intervals along the line of a railroad substantially as and for the purposes specified. I find what represents the equivalent of the battery B, in combination with positive and negative conductors C and Z, two or more electro-magnets for releasing or reversing visible or audible signals, and two or more circuit-closers supposed to be placed at intervals along the line of a railroad substantially for the purpose, and as specified. I find what purports to be the equivalent of the combination of the battery B, conductors C and Z, circuit-closer A, and electro-magnet M, for actuating a visible or audible signal, together with a circuit-closer, wires, and electro-magnet for reversing, releasing, or stopping said signal, substantially as specified.

Q. 14. Please examine the diagram and its written explanation in the paper I now hand you, marked Complainants' Exhibit C C, and state whether the results therein proposed to be accomplished can be practically effected by means of a single battery, and by the use of the same number of line wires as are indicated in said diagram, provided the system of signals therein referred to be arranged and operated substantially in the manner described and shown in complainants' patent, Exhibit A, and shown in Complainants' Exhibits X and Y?

A. It can.

Q. 15. Please read the cross-interrogatories 149 to 154, inclusive, pages 147 and 148, complainants' printed testimony, and say whether, in your opinion, the statements therein quoted are or are not substantially correct as applied to the construction and operation of ordinary telegraph lines?

A. They are substantially correct as appled to the construction and operation of ordinary telegraph lines, and the caution referred to in cross-interrogatory 153 refers to the caution which a line man should exercise in keeping a line in repair, and is intended to impress upon him the need of scrupulously maintaining the insulation of his line.

179 Q. 16. Do the facts set forth in the cross-interrogatory referred to in the last question necessarily have any practical bearing upon the working of the system of railroad signals arranged for operation in the manner contemplated in complainants' patent, Exhibit A?

A. Not very much, for the reason that the ratio of insulation reristance to the conductivity of the line differs so widely in the two cases. For instance, the resistance of a wet insulator might be perhaps 3,000 ohms, while the resistance of five miles of wire would not need to be more than 60 ohms. In this case one wet insulator near to the battery would take off say about the fiftieth part of the current, while on a telegraph line three hundred miles long, constructed of the same size wire, such a wet insulator near the battery would take off half the current, supposing the earth circuit to be used.

Q. 17. From theoretical considerations, have you any reason to suppose that there would be any practical difficulty in successfully op-

erating a system of signals, such as that described and shown in complainants' patent, Exhibit A, over a length say of five miles of railroad, assuming that proper judgment had been exercised in determining the proportionate electrical resistance of the various conductors?

A. None at all.

Counsel for complainants places in evidence a certified copy from the files of the Patent Office of the file wrapper and contents in the matter of letters patent granted Thomas S. Hall, April 21, 1874, number 150,030, for improvement in electric railway signal apparatus, and the same is marked Complainants' Exhibit G G. R. E. Stillwell, examiner, &c.

Q. 18. Please look at the specification in Exhibit G G, and state whether or not you find therein set forth and claimed the combinations or any material part thereof, which form the subject-matter of complainants' patent, Exhibit A?

180 A. I find the first rejected claim of said Exhibit G G to be for substantially the same devices as are referred to in complainant's patent, Exhibit A, if I may understand the word "track instruments" to refer to circuit-closers, also the words "electro-magnets in the signal houses" to refer to the electro-magnets used for the purposes of displaying and releasing the several signals.

Adjourned to 11 a. m., the 15th instant.

SATURDAY, *March* 15, 1879.

Present: Frank L. Pope, one of the complainants, in person; John Van Santvoord, counsel for defendants.

Witness MOSES G. FARMER, appears, and is cross-examined by JOHN VAN SANTVOORD, Esq., counsel for defendant.

Cross-int. 19. Were the electro-magnetic machines, to which you refer in answer 1, machines of your own invention, or machines which were merely constructed by you as a mechanic?

Ans. Some of them were my own machines, and some of them were constructed by me as a mechanic for other people.

Cross-int. 20. Please specify those of them which were of your own invention.

Ans. Some of the electro-magnetic clocks were of my invention; some of the electric locks were of my invention; one of the electro-chronographs was of my invention; I think most of the printing telegraphs were of my invention; some of the fire-alarm telegraphs were of my invention, some of it was of the invention of Dr. Channing; some of the electro-magnetic engines were of my invention, some of them were the inventions of other people; some of the electric torpedoes were of my invention, and some the inven-

181 tion of others; some of electric light apparatus was of my invention, and some the invention of others; the electro-magnetic signal apparatus for railroads was of my invention, and some the invention of others.

Cross-int 21. Have you patented any of these inventions of yours?

Ans. I have.

Cross-int. 22. Which of your inventions mentioned in your 20th answer are in actual use or practice now?

Ans. I am not certain whether the electro-magnetic clock is now or not; much of the fire-alarm apparatus is in use at present; some of the electric torpedo apparatus is in use at present; some of the electric light apparatus may be said to be in use whenever it is wanted; many of my magneto-electric machines are in use at present.

Cross-int. 23. Have you patented your invention or inventions in electro-magnetic signal apparatus for railroads?

Ans. I have not.

Cross-int. 24. When did you make such inventions last referred to?

Ans. As near as I recollect I made the first of them about the year 1856 or 1857.

Cross-int. 25. Did you apply it to use on a railroad?

Ans. I did not.

Cross-int. 26. Did you test it in any way?

Ans. I made a satisfactory working model?

Cross-int. 27. Please describe that apparatus?

Ans. I respectfully decline, because I have not published it, and I retain the invention myself.

Cross-int. 28. Have you published, and are you willing to describe, any other inventions, if there are any others made by you, relating to railroad signals where electricity is used?

Ans. I have not published them, and I am not willing to describe them.

Cross-int. 29. In your former examination in this suit you stated that you had been frequently called to testify in cases of interference, and occasionally in United States courts, in relation to matters of electricity and of other matters; did those cases of interference relate to your own applications for patents, and did the cases in the United States courts relate to your own suits?

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Ans. I think most of the cases of interference referred to my own matters. The cases in the United States courts did not refer to my own matters.

Cross-int. 30. Did you actually construct and put in operation a fire-alarm telegraph; and, if so, where and in what years?

Ans. I did; in Boston, in the years 1851 and 1852.

Cross-int. 31. Is it in use now?

Ans. The system is in use now, and some of the actual apparatus is in use now, to my present belief.

Cross-int. 32. Did you find any difficulty in the adjustment of the metallic conductors which you used in the construction of that fire-alarm telegraph, or did the apparatus answer for practical use immediately on its first being arranged, and without adjustment?

Ans. The adjustment of the metallic conductors was successful from the first.

Cross-int. 33. What was the extreme length of the metallic conductors used in that fire-alarm telegraph?

Ans. I do not remember, but I should say a total of forty miles

and I should think one of the circuits at least was more than four miles in length.

Cross-int. 34. Did you use a closed or open circuit?

Ans. A closed circuit.

Cross-int. 35. Did you try to use that fire-alarm telegraph apparatus with an open circuit, and with what success?

Ans. We tried to use a fire-alarm telegraph apparatus on an open circuit, and with poor success.

Cross-int. 36. What was the trouble?

Ans. Partly in its conception, partly on account of the imperfect insulating materials then obtainable, partly owing to the poor quality of the workmanship put into some portions of the apparatus.

Cross-int. 37. Was the want of success attributable in part to the difficulty of working the fire-alarm telegraph apparatus on an open circuit?

183 Ans. I think an open-circuit fire-alarm telegraph apparatus could be worked better now than it could at that date, because we now have better means for insulating wires. I think the faultiness of the conception had much to do with its ill success. I do not think the open circuit near as well adapted to a fire-alarm apparatus as a closed circuit, because the latter will give warning when the circuit is broken, accidentally or otherwise.

Cross-int. 38. To what do you refer in the words "faultiness of conception" in your last answer?

Ans. I do not think the best plan of using the open circuit was then proposed.

Cross-int. 39. Do you mean by that expression that there are faults or difficulties connected with an open circuit which have to be overcome or removed by actual trial or new expedients?

Ans. No, sir.

Cross-int. 40. Do you mean by the expression "faultiness of conception," that there are difficulties in the use of an open circuit which inhere in that method of using electricity for signalling, or other practical purposes?

Ans. I mean that there are difficulties which inhere in that particular conception as to the manner of using an open circuit, which would not inhere in another and a different method of using the open circuit, and difficulties which do not inhere in the use of a closed circuit.

Cross-int. 41. Please describe the plan or arrangement of using the open circuit in connection with the fire-alarm telegraph to which you have referred?

Ans. I do not recollect perhaps with sufficient precision to describe it acurately, but minute descriptions of it were published and widely distributed in pamphlet form at that date; I think it was also described in Silliman's Journal about the year 1851 or 1852.

Cross-int. 42. Referring to your answer 5, where you used this language: "And as Mr. Pope's arrangement does accomplish the desired object;" please state how you are able to know that fact, and state whether you have seen Mr. Pope's arrangement in actual use on a railroad; and, if so, where and when?

184 Ans. In my opinion Mr. Pope's arrangement, if properly constructed by a competent electrician, properly cared for and operated by a competent superintendent, would, without doubt, accomplish the desired object. I do not remember to have seen it in practical operation on any railroad where I have examined it with such care that I could give a detailed account of its construction, or speak of my own knowledge of the measure of success attained in its working.

Cross-int. 43. Then you mean that those words I have quoted from your answer 5, express your *opinion* that Mr. Pope's arrangement would accomplish the desired object, but do not express that you have seen his arrangement accomplishing the desired object on a railroad? Is that so?

Ans. I should say, yes.

Cross-int. 44. Have you seen or examined Mr. Pope's arrangement which is described in his patent here in suit, at any place or at any time on the line of a railroad?

Ans. I do not now remember that I have.

Cross-int. 45. Please explain what you mean in your answer 42 by the words, "if properly constructed," as applied to Mr. Pope's arrangements, and state fully from your best knowledge and experience what things are required in order to meet that condition?

Ans. With the skill that a competent electrician would possess, having due regard to the dimensions of the cores of the electro-magnets, the dimension of their armatures, the size of the wire used in making the coils to surround these magnetic cores, the space to be occupied by these coils, the number of spires in each coil, the resistance of each coil with reference to the total resistance of the circuit, and to the amount of battery to be used in order to produce the necessary attractive power in the electro-magnet. Reference should be had also to the dimensions and resistance of the wires leading to the circuit-closers. Reference should be had to the material of which the circuit-closers are constructed, so as to avoid oxidation of the parts where the circuit is broken at the circuit-closer. Reference
185 should be had also to the proper insulation of the circuit-closers and to their durability. Reference should be had also to the proper insulation of the battery, the main wires, the leading wires, and the proper resistance of the several branch circuits, so as to produce a nearly uniform, or, at least, adequate lifting power in each signal displaying magnet used. Attention should be paid also to the kind of battery used, so as to secure economy of expense, and certainty of action, in the operation of the battery.

Cross-int. 46. Please compare the arrangement described in Mr. Pope's patent, Exhibit A, and specified in the claims thereof, with the arrangement shown in the sketch, Defendants' Exhibit 10, and state whether they differ from each other; and, if so, in what respect, leaving out of consideration the signal and signal mechanism shown in Exhibit 10.

Ans. I find in Exhibit 10, as in Mr. Pope's patent, one battery having two wires as the prolongation of the poles thereof, and ranged alongside of the railroad track; I also find, in Exhibit 10, two or

more circuit-closers arranged along the line of the railroad, apparently for the purpose of operating a succession of signals as the train passes along. I do not observe upon the sketch, but I suppose that there are intended to be placed electro-magnets, and used in connection with the signals, for the purpose of operating the signals by the combined action of the battery, the wires, conductors, magnets, and circuit-closers, by the agency of the passing train, and I understand that the testimony places the electro-magnets there; hence I consider that they resemble each other, and are substantially the same.

Cross-int. 47. Do you not find, however, a material difference in them in respect to the construction and arrangement of the circuit-closers?

Ans. Mr. Pope does not limit himself to the particular devices for closing the circuits that are figured in this patent. Those devices for closing the circuits figured in Mr. Pope's patent appear to differ in construction from those figured in Exhibit 10.

Cross-int. 48. Please look at Defendants' Exhibit S and state whether, according to the arrangement of the conductors and circuits there shown, you judge that the several circuits therein would be necessarily of equal resistance?

186 Ans. If the several magnets, with their leading wires, which extend to the circuit-closers, were of equal resistance, and the main wires, A and B, were of uniform linear resistance, and the battery and earth always of constant resistance, and the temperature of the conductors always constant, the several branch circuits should have equal resistance.

Cross-int. 49. Do you know of any publications or text-books on electricity which describe the mode of connection, which you find shown in said Exhibit S, for forming two or more circuits, so as to make the several circuits of equal resistance?

Ans. I find this described on page 55 of "Pope's Modern Practice, 1869," already referred to in Complainants' Exhibit R. I cannot now call to mind any other text book in which it occurs. If I do before the conclusion of my testimony I will mention it.

Adjourned to the 17th inst., at 10 a. m.

MONDAY, *March* 17, 1879.

Present: The same parties as before.

Cross-int. 50. Would a person skilled in the art of electricity, and encountering the difficulties referred to in the seventh question of your present examination, where that question alludes to the testimony of defendants witnesses, Hall and Snow, have required the suggestion of Mr. Pope's patent, Exhibit A, in order to know how to overcome them?

Ans. The skill which the competent electrician should possess ought to have led him to expect those difficulties if he constructed the magnets and circuits as it appears they did construct them, and should have taught him beforehand to construct them in a different and better manner to accomplish the desired result, even without any reference to Mr. Pope's patent.

Cross-int. 51. If Mr. Hall's system, as shown by him in
187 Defendants' Exhibit 10, had included a means of equalizing the resistances of the various circuits by the use of resistance coils, would it not, in your opinion, have worked successfully; and, if not, why not?

Ans. If the magnets were properly constructed, and also the circuit-closing devices properly constructed, and the resistances properly equalized, also the signal devices for displaying and releasing mechanism kept in proper order, it would doubtless have worked.

Cross-int. 52. Is it found, according to your experience, economical and safe in practice to rely upon the earth as a return circuit in telegraph lines, or is it usual not to rely thereon, but to employ a metallic conductor for the return circuit?

Ans. It is usually found both safe and economical to rely upon the use of the earth for the return circuit.

Cross-int. 53. When one pole of a battery is connected with the earth is it not customary among electricians to regard that pole as at zero potential or intensity, or as having essentially no charge or intensity, but as being at the potential of the earth, which is assumed as zero?

Ans. If it be assumed at zero, I should say it would; but it is not always assumed at zero. The actual potential of the earth, with reference to the terminal plate of the battery, would depend on the length, conductivity, and other dimensions of what we call the ground wire, or earth wire, or wire which serves to connect the terminal plate of the battery with the earth. It would depend also on the resistance of that part of the circuit which is exterior to the battery.

Cross-int. 54. Assuming the ground wire to be of the usual dimensions, what would this difference of potential amount to?

Ans. It would depend on the resistance of the rest of the circuit. If it were an open circuit, with an ordinary earth wire, the potential of the earth and the terminal plate of the battery connected with it would be practically identical.

Cross-int. 55. Would the potential of said terminal plate then be the same as the potential of the earth at that place?

Ans. It would, if the battery were on an open circuit.

188 Cross-int. 56. Is it not customary among electricians, in discussing electrical problems, to assume the earth as at zero potential, just as in discussing problems of height we assume the ocean level as constant, disregarding temporary and accidental fluctuations?

Ans. Oftentimes—very often—but not always; it would depend on the problem under consideration.

Cross-int. 57. You mean, do you not, that where abnormal resistances in the earth constitute essential features of the problem, the earth could not be correctly assumed as at zero potential, but that where no such conditions existed or were involved in the problem, it would be customary among electricians to assume the earth at zero, just as we assume the ocean level to be constant?

Ans. There would be no difficulty or impropriety in assuming one of your earth plates exactly zero if you please, but the other earth plate could not be assumed to be at zero if there were a current flowing between the two earth plates, and it encountered any resistance in its passage from one earth plate to the other; and the difference of potential between the two earth plates would be expressed by the fraction which has the earth's resistance for an enumerator, and the total resistance of the circuit for a denominator, so the difference of these potentials would be the nearer zero the greater this denominator, and if this denominator were infinity, as it would be approximately on an open circuit, in such case the two earth plates would be at the same potential, practically.

Cross-int. 58. Do you regard the earth as a conductor of practically infinite capacity, just as if it were a globe of copper of the same size?

Ans. Of exactly the same capacity as of a globe of the same size, and of a definite, finite, and calculable capacity when its radius and distance at any time from all the other heavenly bodies is known.

Cross-int. 59. When a circuit is closed through the earth, do you consider that the electricity which leaves one earth plate travels over to the other, or that the earth is a practically infinite reser-
189 voir into which electricity can be passed, or from which it can be withdrawn, without altering its charge as a whole?

Ans. I consider that the electricity passes between the two earth plates the same as it would through any other conductor having the same conductivity and static capacity.

Cross-int. 60. Supposing, as is often the case, that there are hundreds of earth circuits completed through the same region at the same time, how do these various currents keep clear of each other?

Ans. I might refer to Exhibit B, and say that I don't know any better how than I know how the four branch circuits in Exhibit R keep clear of each other in the conductor B. I don't know that they keep clear of each other. I do not think that they keep clear of each other. I think that they influence each other, but I think that they unerringly find their way home if the respective circuits are closed, and not otherwise.

Cross-int. 61. Will the earth, in your opinion, acquire by connection with one pole of a battery a charge of any appreciable amount, or will not its potential be as little affected by the battery as would the level of the ocean by a brook running into it?

Ans. That would depend upon the electro-motive force of the battery and electro-static capacity of the battery, and its other terminal, and would, under ordinary circumstances, be practically inappreciable.

Cross-int. 62. Suppose a battery to have its negative pole connected with the earth, said pole being at zero potential, and its positive pole connected to a wire five miles long, whose other end is connected to the earth, will not this wire have a positive charge of maximum potential at the battery, running down to a low positive potential at the other end where it is connected with the earth, and would it not be properly called a positive conductor?

Ans. If we consider the direction of the positive current as flowing from the first earth, and through the battery, and also through the five miles of conductor to the second earth, and from the second earth through the earth to the first earth, you
190 may call it a positive conductor all the way round. This is the direction in which a positive current circulates, and the positive or copper pole of the battery would be at a higher positive potential than the extreme end of the five miles of wire, where it connects with the earth, and this distant earth plate would be at a higher positive potential than the first earth plate, if there were any resistance in the earth between the two earth plates. So all this conducting substance of the circuit can be considered a positive conductor having reference to the direction which the positive current flows, and of course the wire leading from the positive pole of the battery through the five miles through the earth, could, with propriety, be called a positive conductor, as we assume the positive current to be flowing through it to the earth in virtue of a diminishing potential.

Cross-int. 63. Is it not also true that the end of the wire next the battery has a maximum positive potential in relation to the rest of the system, and the second earth plate has a less positive potential than this maximum?

Ans. Yes.

Cross-int. 64. Suppose that in place of a single wire, as stated in question 62, two parallel wires were arranged, as in Defendants' Exhibit 10, lettered in that exhibit A B, and a connection established at any point from one to the other, would not the condition of the parts of the wires through which the current ran be exactly the same as stated in the two last questions and answers?

Ans. If that connection which ran from one wire to the other offered no appreciable resistance it would.

Cross-int. 65. And if such connection did offer an appreciable resistance would this have any other effect than lengthening the wire by an equivalent amount?

Ans. It would not alter the fact that the point of the wire in connection with the positive pole, the battery would have a maximum positive potential, and be higher than the potential at that point of the wire in contact with the distant earth.

Cross-int. 66. Would it have any other effect than would be produced by an equivalent elongation of the wire?

191 Ans. It would not.

Cross-int. 67. Please consider carefully the following case: The positive pole of a battery is connected with one end of a uniform insulated wire, which runs off five miles, returns, and has its other end connected with the negative pole of the same battery. While the current flows, will not the wire be in the following condition of charge or potential: At the end connected with the positive pole of the battery the wire has a maximum positive charge or potential, decreasing regularly to zero at the point five miles distant; at the end connected with the negative pole of the battery the

wire has a maximum negative charge or potential, decreasing regularly to the point five miles off, where the charge will be zero?

Ans. That depends upon where you assume your zero of potential in the neighborhood of the battery. If you assume your zero of potential in the middle of the battery, that would be the case. If, on the contrary, you assume your zero of potential at the negative pole of the battery, the positive pole of the battery would be at the maximum positive potential, and this positive potential would diminish along the wire over the whole five miles, diminishing still further along the return wire to the negative end of the battery, where, of course, it would be zero. If, again, you assume your zero at the positive end of the battery, the negative potential will be at a maximum at the negative pole of the battery, diminishing along the return wire to the bight, five miles distant, diminishing still further along the outgoing wire to the positive end of the battery, where the negative potential would be zero.

Cross-int. 68. If you assume the zero of potential to be at the negative pole, have you any negative potential at all?

Ans. Not a bit.

Cross-int. 69. Assuming the same condition, would not the whole wire be properly considered as a positive conductor?

Ans. I think so.

Cross-int. 70. But assuming the zero of potential to be in the middle of the battery, would there not be a positive po-
192 tential at the positive pole and a negative potential at the negative pole, and the other conditions as described in question 67?

Ans. It would.

Cross-int. 71. If a wire is connected with the earth, does it thereby acquire a negative or a positive charge or potential from the earth, and in consequence of its connection therewith?

Ans. It acquires whatever charge or potential the earth has at that point.

Cross-int. 72. Do you consider the earth, when one pole of a battery is connected with it, to be virtually a prolongation of the said pole in the same sense as the wires C, Z, in complainants' patent, Exhibit A, are described in said patent as a prolongation of the positive or negative pole of the battery B?

Ans. Certainly, if in completing the circuit it performs the same function equally well.

Cross-int. 73. Suppose the earth to be connected with the positive pole of one battery and the negative pole of another battery, of which pole will the earth then be a virtual prolongation?

Ans. A prolongation of the positive pole of one battery and the negative pole of the other battery.

Cross-int. 74. Did you ever see in operation a circuit-closer operated by the wheels and axle of a locomotive or cars of a train on an insulated section of a railroad track, as described in Pope's patent, Exhibit A?

Ans. To the best of my recollection, I saw what purported to be such at Philadelphia in 1876, but I did not examine it sufficiently

in detail to say of my own knowledge and remembrance that it was such. I believe it to have been such.

Cross-int. 75. Did you examine it so as to know whether there was more than one such circuit-closer in direct connection with the same battery?

Ans. I did not.

Cross-int. 76. Do you know, or can you from your general knowledge estimate, what would be the resistance to leakage
193 between the two parallel rails of such a circuit-closer as is described in Pope's patent, Exhibit A?

Ans. I should think it might vary from less than a hundred ohms, in some cases of moisture, to four or five thousand, or even more, ohms, in some sandy soils and dry seasons, and the magnets and branch circuits might be so constructed as to offer very much less resistance than this, and still be operative.

Cross-int. 77. What would be the least resistance likely to occur in practice in wet weather?

Ans. Taking the average condition of the rail, as to grease and dirt, if a proper attempt were made to insulate it, it might fall as low as ten ohms, but I think it would rarely fall as low as that.

Cross-int. 78. What would be the resistance of the line wire in a line of electric signals ten miles long, arranged as suggested in Mr. Pope's patent, Exhibit A?

Ans. That would depend upon the diameter of the wire and the material of which it is made. Mr. Pope called my attention to an estimate I made for him once of a compound steel and copper wire weighing 284 pounds to the mile, which would offer 50 ohms to 10 miles, or 100 ohms to 20 miles.

Cross-int. 79. Has Mr. Pope ordered any such wire of you?

Ans. Not that I remember of.

Cross-int. 80. Would not the resistance of the ordinary iron wire used for such purposes be about 10 to 12 ohms per mile?

Ans. The best No. 8 iron wire is about 12 ohms to the mile. Nos. 5 and 6 of the best iron, between 8 and 10, perhaps. Any size can be calculated from this data. The best iron wire, weighing 4,400 pounds to the mile, would offer one ohm resistance to the mile, so the resistance of a circuit would be determined by questions of economy in first cost, having due reference to the certainty of working. Nos. 6 and 8 are perhaps six cents a pound at present, so that a No. 8 would cost not far from $22 to $23 a mile.

194 Cross-int. 81. Assuming a No. 8 wire to be used, the resistance of the line would then be about 240 ohms for a line of ten miles in length, would it not?

Ans. It would.

Cross-int. 82. About what, under those circumstances, would be the resistance of the circuits working with a single battery at one end of the line, assuming the circuits to be equalized by the introduction of resistances, omitting the resistance of the battery?

Ans. The resistance of each circuit would be 240 ohms, plus the resistance of the magnet and the wires leading to the circuit-closers.

Cross-int. 83. What would be the least resistance which you would

think it judicious to use in the magnets, and their connection to the circuit-closers?

Ans. I never have had occasion to design such a system, nor have taken the trouble to calculate the necessary dimensions of magnet for displaying a signal; and I do not think, to begin with, that I should use a wire so small as No. 8; and so I should not like to say the smallest resistance proper to be used.

Cross-int. 84. What size wire would you use?

Ans. As large as I could afford.

Cross-int. 85. Would not a No. 6 wire be large enough in your opinion?

Ans. I don't think I should use one any smaller than the compound wire I suggested to Mr. Pope, if I could afford that.

Cross-int. 86. Do you know of any instance where such compound wire has been used in such a combination as you understand is described in Mr. Pope's patent, Exhibit A?

Ans. I do not.

Adjourned, subject to new notice.

195 WEDNESDAY *June, 4th*, 1879.

Present: F. Chamberlin, Esq., counsel for complainants; John Van Santvoord, Esq., counsel for defendants.

Deposition of William H. Markland.

WILLIAM HENRY MARKLAND, called and sworn as a witness on the part of the complainants, deposes and says:

Int. 1. What is your name, age, residence, and occupation?

Ans. My name is William Henry Markland; my age is 45 years; reside in Brooklyn, N. Y., and am an electrical and telegraph instrument manufacturer, and have been engaged in that business about 14 years.

Int. 2. Have you read the patent No. 140,536, dated July 1st, 1873, issued by the United States to Frank L. Pope, for improvements in circuits for electrical railroad signals, and its accompanying specifications, and have you looked at the drawings connected with the same?

Ans. I have.

Int. 3. Have you also read the specifications of John Henry Johnson, dated March 5, 1856, connected with his English patent No. 446, for the invention of improvements in railroad signals?

Ans. I have.

Int. 4. State whether or not you understand the general scope of the invention described by Mr. Pope.

Ans. I do.

Int. 5. Please state whether or not, in your opinion, the specification and drawing of Pope's said patent gives such a description of the invention which it purports to set forth, that a person skilled in the art of application of electricity and electro-magnetism to railroad signalling, would be able from said patent, specification, and drawing

ing, and without other aid, to construct an apparatus which would accomplish the object which said patent purports to describe.

196 Ans. It would.

Int. 6. With that specification and drawing in hand, would a person skilled in the art, as it existed at the date of Pope's patent, have had any difficulty in so constructing such an apparatus, in your judgment?

Ans. I should say not.

Cross-examined by JOHN VAN SANTVOORD, Esq., on the part of defendants:

Cross-int. 7. In what business was you engaged before you became an electrical and telegraph instrument manufacturer?

Ans. My trade is close and electro-plating.

Cross-int. 8. Did you carry on that business on your own account?

Ans. No, sir.

Cross-int. 9. With whom was you last employed in that business?

Ans. With Henry Killam, of New Haven, Connecticut, at close plating, and in the matter of electro-plating with the Ives & Pardee Manufacturing Company, of Mount Carmel, Connecticut.

Cross-int. 10. Is close plating done with the aid of electricity?

Ans. It is not.

Cross-int. 11. In what capacity was you employed by the Ives & Pardee Company, or by any other persons or company who carried on the business of electro-plating, and for whom you did any work in connection with electro-plating?

Ans. With the Ives & Pardee Company I was foreman of the plating room; I had done some work for another party, where I was foreman and journeyman; it was only a small concern.

Cross-int. 12. Did you ever study electricity as a science?

Ans. I can answer that by saying, not as a science, only in a practical way.

197 Cross-int. 13. Did you ever study electricity in a practical way, except as you wanted to know so much about the same as you found necessary to in your business?

Ans. But very little.

Cross-int. 14. Did you ever put up any electric railroad signal apparatus under Mr. Pope's patent?

Ans. I did not.

Cross-int. 15. What instances can you give where you have applied the science of electricity in a practical way?

Ans. That is a very sweeping question; I hardly know how to answer that; I had perfected some printing telegraph instruments while I worked for Mr. Tillotson; I worked at making a part of Mr. Hall's signaling apparatus, and also on something similar for Mr. Pope.

Cross-int. 16. In what year was it when you worked on Mr. Hall's signal apparatus at Mr. Tillotson's?

Ans. I don't remember at this time.

Cross-int. 17. Was it at Mr. Tillotson's also that you worked on something similar for Mr. Pope?

Ans. It was under Mr. Pope's directions; I do not know it was for him; it was while I worked at Tillotson's?

Cross-int. 18. Can you describe the apparatus on which you worked, on what you say was for Mr. Hall, and can you also describe that which you worked at under Mr. Pope's directions?

Ans. My recollection about Mr. Hall's is very faint, and Mr. Pope's I could not go into the details of that.

Cross-int. 19. Please hear the examiner read direct question 4, add your answer thereto, and state whether you understand by the expression, "general scope of the invention described by Mr. Pope," the general purpose of his invention?

Ans. Yes, I do.

Cross-int. 20. Are there any signals shown or described in Mr. Pope's patent?

Ans. I should say not.

Cross-int. 21. Does his patent describe or explain any device or devices for constructing the electric circuits, or any of them, with signals, or signal apparatus?

198 Ans. Yes, it does.

Cross-int. 22. Please point out where.

Ans. The wheels and the axles would certainly connect the magnets which operate the signals.

Cross-int. 23. Are you certain that you understand the question 21? Please hear the examiner read it again before you answer it.

Ans. Well, I will say I do.

Cross-int. 24. What does the patent describe as being accomplished by what you call the wheels and axles?

Ans. I should say it either displays or hides the signal.

Cross-int. 25. Did you have a copy of Mr. Pope's patent and drawing before you while answering questions 21, 22, 23, and 24?

Ans. A part of the time.

Cross-int. 26. What do you understand by the term "respective resistances of the several circuits," as employed in the 5th paragraph of Pope's patent, and explain the meaning of the word "resistance," as you understand it?

Ans. That the resistance of the magnets should differ according to the distance which the aforesaid magnets were from the battery. My understanding of the word "resistance" is the opposition or hindrance to an electric current through a conductor.

Cross-int. 27. Is there any instruction or direction in Mr. Pope's patent for adjusting resistances of any of the circuits? If there is, please quote where you find the same therein.

Ans. No, there is none; and the place where they will be applied would be the guide in such matters.

Cross-int. 28. Are you now in the employ of Tillotson & Co.?

Ans. I am, and have been there about 14 years, with the exception of about seven months, when I was employed by the Western Union Telegraph Company as foreman in making instruments.

Cross-int. 29. Have you ever carried on business on your own account in making telegraph instruments?

Ans. No, I have not.

WM. H. MARKLAND.

Subscribed and sworn to before me, this 4th day of June, 1879.

R. E. STILWELL,
Examiner, &c.

199 *Deposition of Walter O. Lewis.*

WALTER O. LEWIS, called as a witness on the part of the complainant, being duly sworn, deposes and says:

Int. 1. What is your name, age, residence, and business?

Ans. My name is Walter O. Lewis; sixty-four years of age; reside in the city of Brooklyn; and am a journalist.

Int. 2. Are you acquainted with S. C. Hendrickson; and, if so, how long have you known him?

Ans. I am, and have known him for at least twenty-five years.

Int. 3. Did you at any time know of his inventing a railroad signal; and, if so, when?

Ans. I know of his having an arrangement of that kind, which he claimed as his railroad signal, in the spring of 1871.

Int. 4. When did you see it.

Ans. He brought it to my office in New street. He had previously told me that he had an arrangement of that kind, and I had an office which he told me he could bring it to and set it up, and show it to his friends.

Int. 5. Had your office an entrance on Broad street as well as on New street?

Ans. It had.

Int. 6. Do you know whether Mr. Pope, the complainant, and Mr. James N. Ashley, saw this machine while at your office; and if so, how was their attention called to it?

Ans. They saw it at my office. I called their attention to it; first to Mr. Pope, according to my recollection, and subsequently to both of them.

Int. 7. Please give the time, as nearly as you can, and the substance of what you said to them.

Ans. I should say that it was the last of March or the first of April that I met Mr. Pope on Broadway and called his attention to it. I don't remember the words. My recollection is I said that Mr. Hendrickson has got a railroad signal down to my office, and that you had better come down and look at it; it may be of service to you. I don't remember definitely his reply. Subsequently
200 I saw Mr. Ashley and said to him something similar to what I said to Mr. Pope, as before mentioned. After this they both called at my office.

Int. 8. Were you at that time interested in business of this character, and what was your business?

Ans. My business at my New street office was the introduction of electric clocks.

Cross-examined:

Cross-int. 9. Do you know Mr. Thomas S. Hall?

Ans. Yes, and have known him since 1869 or 1870.

Cross-int. 10. Did you ever examine any electric railroad signal of his, or any railroad signal apparatus of his?

Ans. I have witnessed and examined the operation of his electric railroad signal on several occasions. If I am correct in my recollection as to the date, it was first in 1869, in Jersey City, on the Erie railroad. Upon further consideration, I think it was the Morris and Essex. This was in 1869, I think, that I first saw it.

Cross-int. 11. Was the signal which Mr. Hendrickson brought to your office similar to Mr. Hall's?

Ans. Well, the general workings it produced were about the same thing.

Cross-int. 12. Did you ever examine Mr. Hall's railroad signal at Stamford, on the New Haven railroad; if so, in what year?

Ans. I saw it in operation there subsequent to my seeing it in Jersey City; I should think, in the neighborhood of six months later; but whether in the end of 1869 or the beginning of 1870, I can't say.

Cross-int. 13. Was the signal apparatus at Stamford worked by electricity?

Ans. It was.

Cross-int. 14. Was it automatic in its operations?

Ans. I should say it was.

Cross-int. 15. Did that apparatus at Stamford have more than one signal; and, if so, how many?

Ans. It had a signal and rung a bell; whether there was more than one signal, I can't say.

201 Cross-int. 16. Was that signal and bell actuated from more than one point on the New Haven road? If so, how many, and by what means?

Ans. I remember of but one point, and that was by means of a circuit-closer, operated or closed by the operation of the cars passing a certain point.

Cross-int. 17. Was the signal afterwards restored to its first position? If so, how?

Ans. Well, I don't remember about that.

Cross-int. 18. Did the New Haven railroad at that point have a double track?

Ans. I think they did.

Cross-int. 19. Was each track in connection with this electric signal apparatus?

Ans. I don't remember of but one connection with one track, still I don't say but they were both connected.

Cross-int. 20. Please look at Defendants' Exhibit No. 1 A, and state whether or not your recollection now is that Mr. Hall's signal apparatus which you saw at Stamford, as you say, was arranged as shown in the exhibit?

Ans. I should say that the general arrangement is the same as far as it then went, but this is more extended; I do not think the New Canaan track was there at that time; I don't remember about the second track, but presume it was in the system; my memory reverts

more particularly to the circuit-closer near the signal-house on the exhibit.

Cross-int. 21. Did you at the time, or soon after the time that you examined Mr. Hall's signal apparatus at Stamford, write a scientific description of it?

Ans. I remember writing one or two articles, and one of them, I think, was published in the Times newspaper on railroad signals, referring particularly to Mr. Hall's system.

Cross-int. 22. Have you either of these articles with you?

Ans. I have not.

Cross-int. 23. Was Mr. Steven C. Hendrickson in Mr. Hall's employment about his railroad signals when you saw his (Hall's) signals at Jersey City?

202 Ans. I should say he was not in his employ at that time, but think he was a short time after, and, I think, must have been in his employ when I examined his system at Stamford.

WALTER O. LEWIS.

Subscribed and sworn to before me, this 4th day of June, 1879.

R. E. STILWELL,
Examiner, etc.

Adjourned, to meet at Baltimore, June 5, 1879.

Circuit Court of the United States for the District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL COMPANY
vs.
THE HALL RAILWAY SIGNAL COMPANY.

I hereby certify that, on this 5th day of June, A. D. 1879, at my office, No. 50 West Fayette street, in the city of Baltimore, in the district of Maryland, personally appeared before me, Robert Lyon Rogers, a commissioner of the United States in and for the district of Maryland, F. Chamberlin, Esq., solicitor for the complainants in the above-entitled cause, and Thomas S. Hall, representing the defendants; and at the request of said F. Chamberlin, Esq., and Thomas S. Hall, I proceeded to take the following depositions for the complainants in said cause, as follows:

Deposition of Augustus G. Davis.

AUGUSTUS G. DAVIS, a witness for the complainants, being first by me duly sworn according to law, makes oath, deposes and says, as follows:

203 Int. 1. What was your business from 1st of January, 1873, inclusive of spring of that year, and how long had you been in said business?

Ans. I was superintendent of the telegraph of the Baltimore and Ohio railroad during this period, and for nine years preceding the 1st of January, 1873.

Int. 2. State whether or not you had a conversation at any time

between those dates, and, as nearly as you can, when, with complainant, Frank L. Pope, in relation to the introduction of his signal system on the Baltimore and Ohio railroad.

Ans. I had a conversation on that subject with Frank L. Pope some time between the latter part of January and 1st day of February, in 1873.

Int. 3. In consequence of that conversation, state whether or not sample signals were put up at Mt. Clare Junction, on the Baltimore and Ohio railroad, in March, 1873, under your direction, or arrangements made between you and said Pope.

Ans. They were.

Int. 4. State, if you recollect, about what length of road was covered.

Ans. One mile.

Int. 5. State whether or not the signals worked effectively, and for how long, or how otherwise.

Ans. They worked effectively for three or four months, and so worked until they were removed, from no fault in the signal.

Int. 6. Please refer to folios 23 to 25, inclusive, of the evidence of Frank L. Pope in this case, as now read to you, and state whether or not the arrangement and operation of the signals at Mt. Clare embraced substantially the arrangement described in said folios and read to you.

Ans. They did.

Int. 7. In your answer to the 5th interrogatory you state they worked effectively for three or four months; state whether there was any failure during the time they were so in use to effect the result intended by them.

Ans. There was not.

Examination-in-chief closed.

204 Cross-examined:

Cross-int. 1. What means have you of fixing the time when Mr. Pope erected the signals, as to which you have testified, at Mt. Clare, on the Baltimore and Ohio Railroad?

Ans. Simply my memory.

Cross-int. 2. Might it not have been later than March, 1873, that said signals were so put up?

Ans. I think not. I remember waiting until after the frost was out of the ground, so that the battery would not freeze up.

Cross-int. 3. You stated that signals were erected at Mt. Clare Junction; state whether they were audible or visual, or both; and also state the number of signals that were so erected, and state what kind.

Ans. They were visual signals, and there was only one.

Cross-int. 4. Then I understand you that there was but a single signal erected at Mt. Clare Junction, instead of signals as you would seem to state in your answer to the 3d int. Is that so?

Ans. One signal was erected, and I so mean to be understood.

Cross-int. 5. Then, according to the last interrogatory, there would

not have been a series of signals applied at this point which were operated by means of one battery, would there?

Ans. No, there could not.

Cross-int. 6. Please prepare a diagram of the signal as fixed at Mt. Clare Junction; state the kind of battery, the number of cells, and where the battery was located, and the means by which said signal was operated.

Ans. I cannot prepare a diagram of the signals; the number of cells were twenty, in a gravity battery, located in the switch-house adjoining the signal.

Cross-int. 7. State as to the object of the application of this one signal at Mt. Clare Junction; what was the object?

Ans. The object was to show whether a train was on either of the three tracks or roads at their place.

Cross-int. 8. Was this signal displayed and concealed by the action of a train of cars, or was it operated by hand?

205 Ans. It was displayed and concealed, and this was by the action of a train of cars.

Cross-int. 9. What were the means used and applied to the track at the point were it was wished to display the signal or so displaying it?

Ans. There was a circuit-breaker in the track at the end of the mile stretch.

Cross-int. 10. Describe, as near as you can, the mechanical construction and application of the circuit-breaker which you refer to in your last answer.

Ans. I cannot describe it. It has gone from my memory.

Cross-int. 11. State the means used for conveying the electric current from the battery through the circuit breaker to the signal.

Ans. Two wires.

Cross-int. 12. Were the two wires run on telegraph poles, or were they insulated wires, and buried in the earth?

Ans. They were on poles.

Cross-int. 13. State, as near as you can, the mechanical construction of the signal used at Mt. Clare Junction.

Ans. It was composed of two electro-magnets, one working in a cylinder; the opening of one circuit operated the red or danger signal, and the other the white, or all right signal.

Cross-int. 14. Can you give any further description of the mechanism? Was there or not clock-work which caused the signal to operate one way?

Ans. I can give no further description, but I think there was no clock-work or weight.

Cross-int. 15. If this signal at Mt. Clare Junction was an effectual means for the safety of trains, why was not its use continued?

Ans. It was placed there as an experiment only, and it was found that the railroad company did not require such a signal at that point.

Cross-int. 16. Then I understand that the signal did not fulfil the object; am I right?

Ans. No, you are not.

Cross-int. 17. What disposition was made of this signal
206 apparatus at the time it was removed; state who removed it, if you know, and where it is now?

Ans. It was stored in my store-room at Camden station for several months, and then shipped to New York by order of F. L. Pope; I do not know where it is now; the signal was removed by my order by one of my men.

Cross-int. 18. Since the removal of the said signal as you have testified, has the complainant in this case, or Frank L. Pope, erected any other signal or series of signals on the Baltimore and Ohio railroad, or any other railroad, to your knowledge?

Ans. No; not to my knowledge.

Cross-int. 19. During the time this signal was in operation at Mt. Clare junction, how frequently did you witness its practical working?

Ans. Perhaps once a week or once a fortnight.

Cross-int. 20. What means have you of knowing that it worked effectively during the time it was at Mt. Clare?

Ans. Only from the reports of the train men and my inspector.

Cross-int. 21. Then you do not mean to state, from your personal knowledge, that it worked effectively during the term it was there, do you?

Ans. I do not mean to state so from personal knowledge, for I was there only, as I say, once a week or fortnight. I know of its working chiefly from the reports of my inspector and train men.

Cross-int. 22. Were the trains governed exclusively by this signal during the time it was in operation?

Ans. They were not; we had our regular switchmen and semaphore signals.

Cross-int. 23. Were there any rules or orders issued by the railroad company to the engineers to regard this signal at all in the operation of their trains at this point?

Ans. No.

Cross-int. 24. Are you sufficiently familiar with the mechanical structure and mode of operating the signal put at Mt. Clare, as you have stated, to personally erect and put to work such a sig-
207 nal on a railroad, if the said signal, with all the appurtenances coupled therewith, were furnished you?

Ans. Yes; I could erect it and put it in operation.

Cross-int. 25. What personal knowledge have you, aside from this one at Mt. Clare, of the practical operation of automatic signals, such as are now in use on railways?

Ans. None.

Cross-int. 26. Then do I understand that this signal erected at Mt. Clare is the——

[Remainder of this question and answer was omitted in the record.]

Cross-int. 27. In answer to the sixth interrogatory-in-chief you state that the signal put up at Mt. Clare, upon the Baltimore and Ohio railroad, by Frank L. Pope, was substantially the same as a certain apparatus or signal specifically described in certain paragraphs read to you from certain evidence in the case at folios 23 and

25, inclusive. Now, please describe, in your own language, the signal or apparatus so described between said folios and read to you as aforesaid.

Ans. I cannot do that.

Cross-int. 28. What do you mean, then, by saying that the signal put up by Pope at Mt. Clare Junction, on the Baltimore and Ohio railroad, was substantially like that described in said evidence at the folios aforesaid?

Ans. I do not know how to answer that question; I cannot remember the apparatus described in the answer read to me in my examination-in-chief.

Cross-int. 29. Did Pope ever exhibit to you, on or before March, 1873, a drawing of a series of signals to be operated by a single battery on railroad tracks, and explain to you intelligibly the mechanical principles involved in said signals? If so, please state whether or not you fully understood the mechanical principles involved in said signals; and, if so, explain the same as though you were specially interrogated in regard thereto, and explain in the same way any drawing so shown you by Pope, as aforesaid.

208 (Question objected to as introducing new matter, and not being a cross-examination of the witness to anything brought out in chief.)

Ans. He did make lead pencil drawing at the time, but I cannot explain anything about them; I arranged with him to put the signal on, and he did so, and I have stated all I know about that.

Cross-examination closed.

Re-examined:

Int. 30. When did your connection with the Baltimore and Ohio railroad cease, and have you been connected with any railroad since?

Ans. I left the Baltimore and Ohio railroad's employ in February, 1875, and I have not been connected with any railroad since.

A. G. DAVIS.

Subscribed and sworn to before me, this 5th day of June, A. D. 1879.

R. LYON ROGERS,
U. S. Commissioner, Maryland.

209 United States Circuit Court, District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL COMPANY
vs.
THE HALL RAILWAY SIGNAL COMPANY. } In Equity.

Cross-examination of MOSES G. FARMER resumed before Darius Baker, a notary public for the State of Rhode Island, at Newport, on the 8th day of January, A. D. 1880, pursuant to notice as agreed.

Present: Frank L. Pope, one of the complainants, in person, and Simeon E. Baldwin, Esq., solicitor for the defendants.

Examined by Mr. BALDWIN:

Deposition of Moses G. Farmer—(Continued.)

Cross-int. 87. When did you first become acquainted with the specification of Johnson's patent, Complainants' Exhibit "M"?

Ans. I don't remember when I first saw it.

Cross-int. 88. Was it prior to the commencement of this suit, which was September 3, 1875?

Ans. I don't remember that my attention was called to it prior to that time.

Cross-int. 89. Would a person skilled in the art of applying electricity and electro-magnetism to railroad signally, prior to the application for the complainants' patent, which was in 1873, have been presumably acquainted with Hall's patent, No. 97505, of December 7, 1869, for his double-circuit instrument, Exhibit No. 3?

210 Ans. I should suppose his attention would have been called to it; how thoroughly he might have studied it, or how well he might have been acquainted with it, would perhaps be determined by the train of thought he was then pursuing.

Cross-int. 90. Would such a person, also, in 1873, have been presumably acquainted with the reissue of the patent No. 4493 of August 1, 1871?

Ans. He would probably have been aware of it.

Cross-int. 91. Was it the design of that double-circuit instrument, indicated in the specifications of those patents, to provide a method by which one or more electric, visible, or audible signals operated by a passing train, which, in passing, closes an electric circuit, can be kept displayed or sounding by means of a locking-lever until the train in its progress closes another electric circuit, and thereby unlocks the lever and withdraws or silences such signals?

Ans. I think it was.

Cross-int. 92. Do not Exhibits 5 and 6 indicate a practicable method of operating a number of these double-circuit instruments by the use of one battery?

Ans. Exhibit 6 certainly seems to; I do not speak of Exhibit 5, not having seen it.

Cross-int. 93. Did you ever see the model, Exhibit 5, which corresponds to the sketch in Exhibit 6?

Ans. I do not remember to have ever seen it.

Cross-int. 94. If the circuit were closed in the apparatus represented in Exhibit 6, at raise 1, raise 2, raise 3, raise 4, and raise 5, in definite and predetermined succession, would the several instruments operate in the same definite and predetermined succession, one after the other, from the one nearest the battery to that most remote?

Ans. They will, if properly constructed.

Cross-int. 95. Please compare Exhibit 10 and Complainants' Exhibit L, and state whether Exhibit 10 does not correspond substantially to Exhibit L, in so far as it shows a mode of displaying danger and safety signals by the action of a passing train upon a track circuit-closer.

Ans. It certainly appears to.

211 Cross-int. 96. Is Exhibit 6 virtually included, so far as it goes, in Exhibit L?

Ans. I should say it is.

Cross-int. 97. Does Exhibit L add to Exhibit 6 signal apparatus and mechanism in connection with one of the double-circuit instruments?

Ans. The one nearest the battery does appear to.

Cross-int. 98. Had you seen Exhibit L before giving your previous testimony?

Ans. I have no present recollection of having seen it before giving my former testimony.

Cross-int. 99. Please examine Exhibit No. 36, and state whether it would involve the exercise of the inventive faculty, on the part of one skilled in the art of applying electricity and electro-magnetism to railroad signalling, to construct the apparatus shown in Exhibit L, after being acquainted with the two patents for Hall's double-circuit instrument (Exhibit No. 3), patent No. 97505 (Exhibit No. 30), reissue No. 4493, and with the apparatus shown in Exhibit No. 6 and in Exhibit No. 36?

Ans. It would not.

Cross-int. 100. Is the electric telegraph commonly used on railroads to direct the motion of trains, and to signify their location when out of time to station agents and other employees?

Ans. It is, to a large extent.

Cross-int. 101. Should you consider a railroad well managed or properly equipped which did not have such a telegraph along its line?

Ans. I should not.

Cross-int. 102. Is the earth made a part of the circuit on all such lines?

Ans. Most usually, I think.

Cross-int. 103. Have you ever known of a railroad telegraph line of any length where the earth was not used for the return conductor?

Ans. I have not.

Cross-int. 104. Is that, in your judgment, the proper mode of constructing a railroad telegraph—I mean by use of the earth as a return conductor?

212 Ans. It is, in almost all cases.

Cross-int. 105. In what cases would you not advise it?

Ans. On railroad lines of moderate length, when the resistance offered by the earth part of the circuit was as much as 5,000 or 6,000 ohms, and variable.

Cross-int. 106. What do you mean by moderate length—how long?

Ans. Thirty or forty miles, or less.

Cross-int. 107. Have you ever known a railroad telegraph line of thirty or forty miles constructed without the use of the earth for the return conductor?

Ans. I have not.

Cross-int. 108. What is the longest stretch of a railroad telegraph line that you have ever known constructed with an entire metallic circuit?

Ans. I do not remember any one at present.

Cross-int. 109. Do earth currents sometimes affect the working of these railroad telegraph lines?

Ans. I have no experience on that point.

Cross-int. 110. Would the same objections which exist to the use of Hall's railroad signal apparatus, on account of his use of the earth as a return conductor, exist also to the same degree against the use of the earth as a part of the circuit of railroad telegraph circuits of the same length as Hall's signal circuits?

Ans. I think not.

Cross-int. 111. Why not?

Ans. The receiving operator on a railroad telegraph line stands ready to adjust his receiving instrument to the strength of the varying current, while no person is present to adjust Hall's apparatus, if the current should become suddenly and greatly weakened by earth currents, or a change in the earth's resistance.

Cross-int. 112. Is there a mechanical contrivance known as a condenser, which is used to obviate difficulties arising from earth currents?

Ans. Such a contrivance is used in the working of ocean cables to modify the effect of earth currents.

Cross-int. 113. Does it work successfully?

213 Ans. It does, to a greater or less extent.

Cross-int. 114. Does it generally relieve the cable from all practical difficulty in its working due to earth currents?

Ans. Largely.

Cross-int. 115. Owing to the length of the circuit in the Atlantic cable telegraph, would it be, without the use of the condenser or some similar contrivance, much more subject to being affected by earth currents than a short line?

Ans. I think it would.

Cross-int. 116. Have condensers been commonly used and known for a long period of years?

Ans. Ten or fifteen years, certainly.

Cross-int. 117. What is the first instance of their use that you are aware of?

Ans. I don't at this moment remember their use on cables prior to 1865, when the Atlantic cable was being laid.

Cross-int. 118. Is the condenser a comparatively inexpensive article to construct?

Ans. I should be inclined to say not; it will depend upon their size; they can be made for from one dollar to twenty thousand dollars apiece.

Cross-int. 119. Is Exhibit R arranged with a design of making the resistance of the several circuits equal?

Ans. Such appears to be the design.

Cross-int. 120. Is that the principal design and merit of the arrangement?

Ans. It appears to be a part of the design and a part of the merit; this design is also intended to lessen the battery expense by supplying many sounders from one battery and distributing the currents equally among them.

Cross-int. 121. Is the equalization of resistances in this exhibit secured by making the different circuits equal in length, and using the same sized wires and placing the battery near to and opposite the centre of the line of the sounders?

Ans. The position of the battery is immaterial in that part of the circuit from A, through E to B; that is, it makes no difference
214 as to the equalization of the resistances whether the battery E be placed nearer to A than it now is, or nearer to B, its position between A and B being immaterial; but the resistances in 1, 2, 3, and 4 are equalized by making them of the same material, of the same length, and of the same cross-section.

Cross-int. 122. In Exhibit 8 are the various circuits, which may be closed in connection with the battery, equal in length?

Ans. I should say not, apparently.

Cross-int. 123. Would it involve the exercise of the inventive faculty on the part of one skilled in the art of applying electricity and electro-magnetism to railroad signalling, as it existed in 1870, and who was acquainted with the arrangement shown by complainants' Exhibit R, to construct the arrangement represented by Exhibit 8?

Ans. I should say not, to any great extent; perhaps not at all.

Cross-int. 124. What do you find in common in Exhibit R and Exhibit 8, and which lead you to think that little, if any, of the exercise of the inventive faculty would have been required in the case put?

Ans. The distant end of the prolongation of one of the poles of the battery marked "main wire B," in Exhibit 8, is in near proximity or close apposition to the hither or near end of the "main wire A," which is the prolongation of the other pole of the battery. The branch circuit, "B 3," from the "main wire B," seems to pass through track circuit-closer marked "*Track circuit-closer to reverse dang. and safety sig.* 3;" thence to signal marked "S 3;" thence to signal marked "D 3;" thence by wire marked "A 3" to "main wire A," and it seems intended to be of the same length as the branch circuit "B 1," which crosses the railroad track at "T 1;" then it leaves "*c* 1" and passes on to "S 1;" then follows the wire "*d* 1" to signal "D 1," and ought apparently to pass through and by "A 1" to the main battery wire A, so that these two hand [branch?] circuits, "B 1" and "B 3," would
215 appear to be equalized, as the branch circuits are in Exhibit R.

Cross-int. 125. Which exhibit did you refer to particularly in your answer to question 5, page 154, of the complainants' printed evidence, folio 609, as the one showing a series of circuit-closers and a series of signals?

Ans. I do not remember; but I should think it probable that it was Exhibit 4 and Exhibit 9.

Cross-int. 126. Suppose that a person skilled in the art of applying electricity and electro-magnetism to railroad signalling was,

after the date of the reissue No. 4493, in 1871, acquainted with the apparatus shown on Exhibits 4 and 9, and also with the apparatus, Exhibit R, for operating a number of branch circuits of equal resistance by the use of one battery, would it, in your judgment, involve the exercise of the inventive faculty on his part to construct an apparatus similar to Exhibits 4 and 9, except that the several branch circuits should be operated by the use of one battery, as in Exhibit R?

Ans. I do not see in Exhibits 4 and 9 any single battery with the prolongations of its poles arranged along the lines of railroad, and provided with devices to maintain the circuits closed for the necessary time for the display of signals. I do not see illustrated there any series of circuit-closers that would release a signal after it was once displayed by use of one and the same battery, and I think it would be needful for a person to exercise his inventive faculty to so manage the system thus illustrated by selecting proper circuit-closers that were already known, or by inventing others adapted to the purpose, and to so combine them with a single battery and a single pair of wires, and the necessary circuit-closers and signalling instruments, that the various signals could be successively shown and withdrawn by the passing train, making use of a single battery and a single pair of leading wires. He would have to study as to where it would be best to place his battery; what kind of a circuit-closer it would be best to use, and what kind of displaying magnets it were best to use; and, in general, to reconstruct the system here shown. To operate successfully with a single battery a single pair of line wires, and their various branch circuits, would, I think, involve the exercise in some degree of the inventive faculty.

216 Cross-int. 127. In the foregoing answer, did you assume that Hall's double-circuit instruments, with his signal apparatus attached, as described in his patent and reissue, Exhibit No. 3 and Exhibit No. 30, were included in the apparatus represented by Exhibits No. 4 and No. 9?

Ans. It might be included, and that is one of the devices that might be selected.

Cross-int. 128. Assuming that you use a stationary battery, would it be of any especial consequence where that battery is placed?

Ans. Not if the branch circuits were to be arranged as in Exhibit R.

Cross-int. 129. Are not the instances known to you in which, at a particular place, the earth has generally or often failed to act as a reliable conductor in a circuit, mainly those of an entire rock formation?

Ans. Yes.

Cross-int. 130. Would not the use of an entire metallic circuit in a system of railway signals, in ordinary cases, involve more expense in supervision and repairs of the main return wire, and the resistance coils and appliances of the branch circuits, than the use of the earth as a part of the return circuit?

Ans. It would, I think.

MOSES G. FARMER.

It is stipulated by both parties that the complainants may re-examine Mr. Farmer as to the matters brought out in his cross-examination either orally or by written interrogatories, to be prepared by the complainants and shown to the defendants, in order that they may state objections to their form, if any, and then transmitted to Mr. Farmer, to be answered by him in writing at his convenience, and that in such case the defendants shall afterward have an opportunity, if they desire it, to recross-examine the witness orally or in writing, as they may choose, on the same.

Subscribed and sworn to before me, this 8th day of January, A. D. 1880, at Newport, R. I.

DARIUS BAKER,
Notary Public.

217 *Deposition of Moses G. Farmer*—Continued.

Redirect int. 131. What office is performed by the double circuit-closer, as shown in the drawing of Hall's patent No. 97,505?

Ans. The office appears to be that of displaying a signal after the armature A is attracted by the electro-magnet B, until it is released by the motion of the armature D towards the electro-magnet E.

Redirect int. 132. Does it show any method of operating a signal except by means of the intervention of a secondary battery?

Ans. It does not.

Redirect int. 133. Does Exhibit L show any means of causing more than one signal to be exhibited by the action of a passing train?

Ans. No.

Redirect int. 134. Does Exhibit L show any way of releasing or reversing any signal whatever by the action of a moving train?

Ans. No.

Redirect int. 135. Suppose that the model of a track circuit-closer, when actuated by the pressure of the hand, operated a signal successfully, would this fact necessarily prove that it would do so when actuated by the momentary impact of the wheels of a rapidly moving train upon the lever?

Ans. It does not.

Redirect int. 136. Does the drawing in Exhibit L show a circuit-closer which is closed momentarily, or continuously for a period of some seconds, when actuated by a rapidly moving train?

Ans. It shows a circuit-closer which is closed momentarily by a rapidly moving train.

Redirect int. 137. In order to display a signal like that represented by Complainants' Exhibit G, by the action of electro-magnetism, how long would the circuit in which the signal magnet is included need to be continuously closed?

Ans. Probably one or more seconds, depending upon its construction and the amount of battery used.

218 Redirect int. Suppose the instrument designated in Exhibit L as "Model Track Circuit-closer Raise 1" were constructed of full size, and so placed as to be depressed by the passage, at right

angles, across the short end of its lever, of the wheels of a railway train moving at the rate of twenty miles an hour, how long would the circuit be continuously closed by its action?

Ans. Not more than the twentieth of a second.

Redirect int. 139. In your opinion, could a signal like that shown in Exhibit C be successfully displayed by connecting it directly in circuit with a circuit-closer like that referred to in the last question, and operating the latter by a moving train, as therein stated?

Ans. I should think not.

Redirect int. 140. Assuming the track circuit-closer in Defendants' Exhibit 36 to be like that represented in Complainants' Exhibit D, and the signal machines to be like those represented in Complainants' Exhibit F, Hall's patent No. 103,875, would the impact of the wheels of a rapidly moving train close the circuit sufficiently long to cause the signal to be properly exhibited, if they were directly connected together in the same electric circuit?

Ans. I think not.

Redirect int. 141. Can you conceive of any way in which a condenser could be applied to Hall's system of signals, shown in Complainants' Exhibit and Defendants' Exhibit 8, so as to eliminate or diminish the interference caused by earth currents or atmospheric electricity?

Ans. I cannot.

Redirect int. 142. In your answer to cross-int. 123, did you understand "the arrangement shown in figure 8" to refer to the arrangement for equalizing the distribution of the current from a single battery between several branch circuits, or to the entire arrangement of circuits, circuit-closers, and signals in connection with a line of railway?

Ans. I understand the arrangement to be a plan for equalizing the distribution of the current from a single battery between several branch circuits.

219 (The defendant objected to above interrogatories 141 and 142, as leading; also to above interrogatories 137, 139, and 140, as not germane to the cross-examination; which objections were taken before and at the time when said interrogatories were put respectively.)

MOSES G. FARMER.

220 And the evidence for defendant as filed in the case is as follows, viz:

United States Circuit Court, District of Connecticut.

ELECTRIC RAILROAD SIGNAL COMPANY

vs.

THE HALL RAILWAY SIGNAL COMPANY.

Defendant's evidence taken before E. E. Marvin, special examiner, at New York City, March 30, 1877.

Messrs. Hall & Perkins appeared for the complainants.

Messrs. Van Santvoord & Baldwin appeared for the defendants.

ALVAH W. HALL, a witness produced on the part of the defendants, sworn:

Int. 1. What is your name, age, residence, and occupation?

Ans. My name is Alvah W. Hall, my age is twenty-four,
221 my residence is New York City, and I am a commission salesman. I am for myself, and have been so employed for about a week; am selling for several houses. I am the son of Thos. S. Hall; and have been engaged in putting up lines of signals under his system and containing his invention for several years, and know of the application by him of such signals to the railroad at Stamford, Conn., in the year 1869. I visited that work in the fall of 1869, at one of my vacations from Yale Scientific School. The diagram Exhibit 1 A correctly represents the signals that I then saw.

Int. 2. Explain that diagram.

Ans. This diagram represents the application of Thos. S. Hall's signals as I saw them at Stamford, Conn. It consists of nine circuit-closers, marked "raise" and "reverse," in combination with three electro-magnets and one battery for raising and reversing an audible signal, situated some quarter a mile from a highway crossing. On the down track of the N. Y. & N. H. R. R. there was a track circuit-closer which was acted upon by passing trains. The wheels of the train closing the track circuit-closer established an electric current from the battery X to track circuit-closer *a* by wire 1; and through circuit-closer *a*, wire 2, to electro-magnet *m*; through said magnet to battery X through wire 3. Said magnet *m*, being vitalized, closed a second circuit-closer *k*. A circuit was thus established from battery X, wire 3, circuit-closer *k*, wire 4, electro-magnet *o*, wire 1, to battery X. An audible signal was thus given by vitalizing magnet *o*; this audible signal being sounded until the train, which was approaching the highway crossing on the down track, had passed said crossing, when a second electric current was established by the train, through circuit-closer *b*, when the bell would cease to operate.

The action of the train upon circuit-closer *b* was as follows:

The train closing circuit-closer *b*, an electric current was established from battery X through wire 1, to and through circuit-closer *b*, through wire 5, to an electro-magnet *p*, to and through said
222 magnet to battery X. This magnet, being vitalized, broke the circuit which had been established through circuit-closer *k*, by the action of the train on circuit-closer *a*, and the audible signal returned to its normal condition. In the same manner a train on the outward or up track, when a quarter of a mile from the highway crossing would set the audible signal at the crossing in operation; this signal remaining in operation until the train had passed the crossing, when the signal would stop ringing.

This application was also applied to a third track, being the New Canaan R. R., a single-track road. The trains on this road, when a quarter of a mile from a highway crossing, either way from the crossing, would operate on circuit-closers, which would operate the audible signal at the crossing, said signal being continued in operation until the train had passed the highway crossing; in this application I observed nine track circuit-closers, three electro-magnets

operated by one battery, to cause an audible signal to be sounded, and stopped, at the highway crossing, by the operation of moving trains.

In combination with the audible signal, a secondary signal was displayed; this auxiliary signal was a visual signal, and so long as the primary signal was in operation, the visual signal would be displayed; and when the primary signal was returned to its normal condition, the auxiliary or visual signal would fall out of sight, or cease being displayed.

The operation of this secondary signal is as follows: I have remarked that, by the closing of circuit-closer *a* by a train, a second circuit-closer *k* was closed, which established the current to sound the audible signal. At the same time that circuit-closer *k* was closed, circuit-closer *h* was closed, and a circuit was formed from the auxiliary battery Y, through wire 6, circuit-closer *h*, wire 7, electro-magnet *s*, wire 8, to the auxiliary battery Y. This electric current being established, through electro-magnet *s* of the auxiliary signal, the visual signal would be displayed so long as circuit-closer *h* was closed. I have stated that the train, closing circuit-closer *b*,
223 had established a circuit through electro-magnet *p*, which had broken the circuit established through circuit-closer *k*. At the same time that the circuit is broken through circuit-closer *k*, the circuit is broken through circuit-closer *h*, and the electro-magnet *s* becoming inoperative, the auxiliary visual signal falls, by gravity, out of sight.

In my examination of this work I found four circuit-closers in combination with two electro-magnets operated by one battery, to actuate the audible signal; I also found five track circuit-closers in combination with two electro-magnets operated by one and the same battery to stop the action of the audible signal. In addition to this audible signal I found a secondary signal, operated by a separate battery, in connection with a circuit-closer and an electro-magnet, for displaying and concealing this auxiliary signal.

This drawing, Exhibit 1 A, is an exact representation of what I saw first at Stamford, Conn., in the fall of 1869; I think at Thanksgiving vacation, and which I saw several times afterwards, and which at said first time was explained to me by my father as I have now explained it. My father had explained this same thing to me before this time at my visits home, and on his visits to New Haven at least six months before I first saw it there in operation.

In the fall of 1871 I became connected with my father in the electric signal business, at which time he was equipping the Grand Central Depot, New York & Harlem R. R. with his signals.

At first I was in the employ of the Harlem R. R. in putting up Hall's signals in the depot and on the road out to Mott Haven Junction.

(Counsel for defendants offer in evidence the diagram referred to above by the witness, which is marked Defendants' Exhibit No. 1 A, E. E. M., Ex'r, March 30, 1877.)

Int. 3. Please look at the diagram I now show you, and state what it represents.

224 (Counsel for defendants offer in evidence the diagram which is marked Defendants' Exhibit No. 2, E. E. M., Ex'r, March 30, 1877.)

Ans. It represents the application made by Thos. S. Hall, at the Grand Central Depot, New York city, of his system of signals, in the fall of 1871. By the use of one battery and twenty-four circuit-closers, together with twenty-five electro-magnets, a code of signals was given to the switch tender. I have examined the details of all this drawing and the descriptive remarks, and find that the drawing and the descriptive remarks are correct. I will explain the operation of the circuit-closer No. 1, to set the signal and the corresponding circuit-closer for reversing the signal, also No. 1.

The train dispatcher from the Grand Central Depot desiring to have the switch of track No. 1 turned to admit a train on that track, notifies the switch tender in the following manner:

By closing circuit-closer No. 1, a circuit is established from battery X, wire B, to and through circuit-closer No. 1, by wire H^1, to and through the raising magnet on double-circuit instrument No. 1, branch wire F^1, wire A, to battery X.

This raising magnet No. 1, of double-circuit instrument No. 1, being vitalized by the establishment of an electric current from battery X, closes a second circuit-closer C.

A circuit is thereby established from battery Y, by wire K, to and through circuit-closer C, wire H, to and through electro-magnet S^1, wires w^1 and N, to battery Y.

The establishment of this circuit vitalizes magnet S^1, of signal instrument No. 1.

This magnet being vitalized, by the attraction of its armature displays a signal to the switch tender.

This signal will remain displayed so long as the current established from battery Y and circuit-closer C is complete.

So long as signal No. 1 is displayed, a third electric cir-
225 cuit is established, from battery X, wire A, branch wire R^1, to and through circuit-closer E, wire t^1, wire V, to electro-magnet of a bell at switch tender's shanty, through that magnet and wire B, to battery X.

This magnet will be vitalized and the bell will ring so long as the circuit is complete from battery X to circuit-closer E.

Said circuit-closer E will remain closed so long as the circuit is complete from battery Y, circuit-closer C, magnet S^1 of signal instrument No. 1.

The switchman, being notified by the ringing of the bell at his shanty and the displaying of the track signal of track No. 1, turns said switch; then he reverses said signal by means of reversing circuit-closer No. 1.

By closing reversing circuit-closer No. 1 a circuit is established from battery X by wire B, to and through reversing circuit-closer No. 1, wire W^1, to and through reversing magnet of double-circuit

instrument No. 1, wires F 1^1 and A, to battery X. The circuit having been established through the reversing magnet of double-circuit instrument No. 1, breaks the circuit previously existing from battery Y, circuit-closer C, and magnet S^1 of signal instrument No. 1, the armature of the signal magnet being released thereby, the signal which had been displayed will fall out [of] sight by its own weight.

The circuit being broken through circuit-closer C and signal magnet S^1 of signal No. 1 breaks the circuit which has been established from battery X to circuit-closers E and bell at switchman's shanty, and the bell will cease ringing.

In like manner the remaining eleven circuit-closers for raising their eleven other respective signals are operated, and also the remaining other eleven circuit-closers for reversing the signals.

Int. 4. What is this instrument which I now show you?

Ans. It is a double-circuit instrument.

(Defendants' counsel offer in evidence exhibit, which is marked Def'ts' Exhibit No. 3, E. E. M. Ex'r, March 30, 1877.)

226 Int. 5. How does Def't's Exhibit No. 3 compare with double-circuit instrument which you have referred to as composing a part of Mr. Hall's system of signals in the Grand Central Depot, and which you have pointed out in the diagram Def't's Exhibit No. 2?

Ans. It is the same thing.

Int. 6. Describe your father's system of railroad electro-magnetic signals, which you say you assisted in putting up on the Harlem R. R. in 1871. Describe so much thereof as will explain the principal and operation thereof

Ans. I will explain this by a diagram which I hold. This system consisted of a series of signals placed on the line of the R. R. and operated by passing trains between 42d street, N. Y. city, and Mott Haven Junction, where the Hudson River R. R. joins the Harlem R. R. These signals consist of audible and visual signals. Circuit closers, placed in proximity to the R. R., were operated upon by passing trains, in combination with visual and audible signals, which were operated by a battery. A train closing circuit-closer *a*, on the outward track, formed an electric circuit from battery X, through wire C, to and through circuit-closer *a*, wire D, to and through an electro-magnet G and wire E, to battery X. The circuit thus formed through electro-magnet G, completed another circuit through circuit-closer H, from battery Y, wire J, to and through circuit closer H, wire K, to and through an electro-magnet L, wire M, to battery Y.

The completing of the circuit caused a visual signal to be displayed, which was kept in this position so long as this circuit was complete.

So long as this signal was displayed, a circuit-closer N was closed, which completed a circuit from battery X, wire E, to and through circuit closer N, wire P, to and through an electro-magnet R, of a bell, wire C, to battery X.

Thus the train by closing circuit-closer *a*, set both visual and audible signals, which would remain in operation until the
227 train had closed circuit-closer *b*, when the signals would be

operated upon, the visual signal falling out of sight, and the audible signal cease sounding.

The operation of the train upon circuit-closer *b* is as follows:

Circuit-closer *b* being closed, a circuit is formed from battery X, wire C, and C^1, to and through circuit-closer *b*, wire S, to and through electro-magnet T, wire E, to battery X.

Electro-magnet T being vitalized by the completion of this circuit, breaks the circuit established from battery Y, through circuit-closer H and electro-magnet L, whereby the visual signal is removed from sight.

The breaking of said circuit also breaks the circuit established from battery X, circuit-closer N and electro-magnet R, of the bell, and the bell ceases operating.

(Diagram referred to put in evidence and marked Defendants' Exhibit No. 4, E. E. M., Ex'r, March 30, 1877.)

Int. 7. Please describe with the aid of diagram the application of electro-magnetic signals made upon the Harlem R. R. where the two tracks cross each other between 50th and 60th streets, in the year 1871.

Ans. I will do so to-morrow morning, when I hope to have a diagram for that purpose.

Int. 8. What do the model and sketch which I know show you represent?

(Defendants' counsel offer in evidence a model and sketch which are placed in evidence, and marked respectively Defendants' Exhibit No. 5, E. E. M., Ex'r, March 30, 1877, and Defendants' Exhibit No. 6, E. E. M., Ex'r, March 30, 1877.)

Ans. The sketch represents the model, and when I describe the one I describe the other. It represents an application of wires in connection with electro-magnets which were operated by one battery, and which I put up in the shops of the Hall Railway Signal Co. at West Meriden, Conn., in December, 1872, plans being furnished me for the construction of the same by my father, and it was put up under his personal supervision.

228 Five double circuit instruments like Defendant's Exhibit No. 3 were arranged on the wall of the room on shelves, as represented in the model Exhibit 5, in connection with the wires and the battery, precisely the same as shown in Defendants' Exhibit No. 5. I now describe from the sketch Defendants' Exhibit No. 6. From each pole of the battery was run one wire, marked respectively A and B. Circuit-closing points were established at points marked Raise 1, Raise 2, Raise 3, Raise 4, Raise 5, Reverse 1, Reverse 2, Reverse 3, and Reverse 4. Connection was made at each one of these circuit-closing points from battery wire A by branch wires A^1, A^2, A^3, A^4, A^5, $A1^1$, $A2^1$, $A3^1$, $A4^1$. Connections were also made from battery wire B to the two top binding-screws of each double-circuit instrument magnet by wires B1, $B1^1$ B2, $B2^1$, B3, $B3^1$, B4, $B4^1$, B5, and $B5^1$.

From the lower left-hand binding-screw of each double-circuit

instrument a wire was run to circuit-closers, "Raise 1" by wire b1, Raise 2 by wire b2, Raise 3 by wire b3, Raise 4 by wire b4, Raise 5 by wire b5.

From the lower right-hand binding-screw of each double-circuit instrument a wire was run to each reversing circuit-closer, Reverse 1 by wire c1, Reverse 2 by wire c2, Reverse 3 by wire c3, Reverse 4 by wire c4.

By closing any or all of these circuit-closers, circuits would be established through the electro-magnets.

Each circuit-closer being connected with its corresponding magnet; by closing circuit-closer, marked Raise 1, a circuit would be formed from battery X, wire A, branch wire A1, to and through circuit-closer Raise 1, wire b1, to and through electro-magnet wire B1, wire B, to battery X. The establishment of this current vitalizes electro-magnet in double-circuit instrument, to which wires b1 and B1 are connected.

In like manner any or all of the circuit-closers may be closed, vitalizing their respective magnets.

It will be seen that all circuit-closers are connected with battery wire A by branch wires, and that all magnets are connected to battery wire B by branch wires.

229 The double-circuit instruments are designated in this sketch by the figures 1, 2, 3, 4, and 5.

Int. 9. Were these double-circuit instruments full size?

Ans. Yes, sir; they were similar to Defendants' Exhibit 3.

Int. 10. Were any signals used in this line or operated therefrom that you recollect of?

Ans. Not at the time I put this up. It represents all that I put up at the time.

Int. 11. Was this application which was represented in Exhibits Nos. 5 and 6 kept secret by your father?

Ans. No, sir; they were not. My father showed them to a number of railroad men, as soon as completed, and took great delight in showing parties interested how he had overcome the difficulty of requiring a battery for each signal.

Int. 12. Was this application also used by your father upon any line of railway; if so, when first, on what road, and with what result?

Ans. Yes, sir; it was. My father immediately explained to C. F. Hatch, the general manager of the Eastern R. R., Mass., the improvement, who gave orders to have his system of signals altered as soon as it was possible, and changed to this system, like Exhibits 5 and 6.

My father immediately went to work preparing to alter over the signals which were then in operation on the Eastern R. R., and to manufacture an entire new set of track circuit-closers, which became necessary in altering the signals on the Eastern R. R. This consumed about nine months during 1873; and the work of putting the signals on the road commenced in December, 1873, and was finished in February, 1874. The battery was put up in Salem, Mass.; the line of signals extending from Salem to Lynn, a distance of about

five miles. We found that in order to raise a signal at Lynn, making an electric circuit of ten miles, the battery had to be of such strength that it entirely destroyed the circuit-closers in the signal nearest the battery. In fact, it burned the circuit-closers at
230 that point. We experimented on this for some two weeks, when we were obliged to abandon the system, we having proved it impracticable in the working of our signals.

Int. 13. What occasioned the employment of so much as nine months in that work?

Ans. It became necessary to make an entire new set of special tools, the improvement necessitating the change of every instrument.

Int. 14. Were you personally engaged in the work of making this application to the Eastern railroad?

Ans. I was, sir.

Int. 15. Was the difficulty in this application overcome; and, if so, how?

Ans. Yes, sir; entirely, by the arrangement of the battery wires, as shown in the model that I here show.

(Defendants' counsel offered in evidence the model referred to, which is marked Defendants' Exhibit No. 7, E. E. M., Ex'r, March 30, 1877.)

Int. 16. Please describe it.

Ans. This model represents the arrangement of the battery wires as they are now operating electric signals put up by the Hall Railway Signal Co. on the Easern railroad, Boston, Lowell & Nashua railroad, Boston & Albany R. R., & Old Colony railroad. This arrangement of wires represents the system as we applied it on the Eastern railroad, and which entirely ovecame the difficulties which I have before referred to.

Int. 17. What is the main difference between the arrangement shown by Exhibits Nos. 5 and 6 and Exhibit No. 7?

Ans. It consists of the method of equalizing the circuits.

Int. 18. By what?

Ans. By an arrangement whereby we bring in the earth into the circuit.

231 Int. 19. What does the drawing which I now show you represent?

(Defendants' counsel place in evidence a drawing which is marked Defendants' Exhibit No. 8.)

Ans. It represents the application of the electric signals applied on the Eastern railroad, February 14th, 1874, by The Hall Railway Co., in accordance with Defendants' Exhibit No. 7.

Int. 20. Have you read the writing on the bottom of Exhibit No. 8, and is it a correct description of the method of operation shown in that drawing?

Ans. I have; and it is correct.

Int. 20*a*. Please produce the diagram which you promised to do in your answer to int. 7, showing the application of your father in

1871, on the Harlem R. R., of railroad signals, between 50th and 60th streets, and describe the same.

Ans. I produce the diagram, which is marked Defendants' Exhibit 9, and is upon the same sheet of Defendants' Exhibit No. 4, being a continuation both of the railroad tracks and of the signal system. Both Exhibits Nos. 4 and 9 show the track in duplicate, the upper ones showing merely the positions of the signal houses and circuit-closers along the tracks, and the bottom one, a view of the same tracks together with the arrangements of the wires and the instruments and apparatus which compose the system.

In the arrangement of the electric signals as shown in Defendants' Exhibit 9, the train dispatcher at the Grand Central Depot controls the movements of all trains by an arrangement of circuit-closers placed in his office, in connection with two visual signals placed at 53d and 56th streets, in connection with an audible signal situated in his office.

The normal condition of the visual signal at 56th street (said signal being a signal for all inward trains) was "safety," while
232 the normal condition of the 53d street signal (said signal being a signal for all outward trains) was "danger."

A right of way was thus given to all inward trains except when said signals were actuated upon by the train dispatcher by circuit-closers placed in his office for that purpose.

An inward train approaching signal A, finding the signal in its normal condition, that is, of "safety," would proceed; the engineer being aware that the signal B, at 53d street, for outward trains was in its normal condition, that is, "danger;" the arrangement of these signals being such that signals A and B cannot show the same signal at the same time.

The engineer of an outward train finding signal B at "safety," would proceed, knowing that signal A for inward trains was set at "danger;" for by the arrangement of the system, in no case could both signals, A and B, show the same signal at the some time.

Signals A and B being in their normal condition, that is, A at "safety" and B at "danger," the train dispatcher desiring to give the right of way to an outward train by signal B, and to stop inward trains by signal A, closes a circuit-closer *a* in his office.

By closing said circuit-closer, a circuit is established from battery X, to and through wire *b*, to and through circuit-closer *a*, through wire *c*, to an electro-magnet G, through said magnet by wire *d* to battery X. A circuit thus being established vitalizes electro-magnet G, which closes a circuit-closer H.

Circuit-closer H being closed, a circuit is established from battery Y, wire *e*, to and through circuit-closer H, wire *f*, to and through an electro-magnet L, wire *g*, to battery Y.

A circuit being established through electro-magnet L, it attracts its armature and displays the signal A at danger.

This signal will remain at danger so long as the circuit is complete through circuit-closer H.

Signal A being displayed at danger, it closes circuit-closer
233 N. A circuit is thus established from battery Z, wire *h*, to

and through circuit-closer N, wire *k*, to and through an electro-magnet D, wire *l*, to battery Z.

A circuit being thus established through circuit-closer N and magnet D of signal B, its armature will be attracted, and the danger signal will be withdrawn from sight, and this leaves a pane of glass, behind which the danger signal was formerly displayed, without anything behind it, which thus indicates safety.

This action of signal B closes a circuit-closer O, and establishes a circuit from battery X through wire *d*, circuit-closer O, wire *m*, electro-magnet E of bell R, to wire *b*, to battery X.

The closing of circuit-closer O completes the circuit through electro-magnet E, which causes the audible signal R to be sounded so long as the circuit remains complete. The magnet E and bell R are in the train-despatcher's office. The sounding of this audible signal announces to the train dispatcher that he has, by closing circuit-closer *a*, displayed a signal of danger to incoming trains at A and a signal of safety to outgoing trains at B.

This audible signal R will sound so long as signals A and B are in the positions last described, and until the outgoing train has closed a circuit-closer *q*, or until the train dispatcher has closed circuit-closer *r* in his office.

The outward train finding signal B at safety, proceeds past the signal B, and when it has reached circuit-closer *q* it closes it, and by doing so a circuit is established from battery X to and through wire *b*, circuit-closer *q*, wire *s*, electro-magnet T, wire *d*, to battery X.

The completion of this circuit and the vitalizing of electro-magnet T opens or breaks the circuit established through circuit-closer H and electro-magnet L.

The breaking of this circuit allows signal A to be acted upon by its gravity and the signal resumes its normal condition, which is one of safety.

The signal so resuming its position breaks or opens the circuit established through circuit-closer N and magnet D of signal B, allowing that signal to resume its normal position of danger.

234 Signal B, so resuming its position of danger, breaks or opens the circuit establisher through circuit-closer O and magnet E of audible signal R, allowing this signal to stop sounding.

The train dispatcher is informed, by the cessation of the audible signal, that the outward train has reached the point at which circuit closer *q* is situated, and that the signals A and B have resumed their normal conditions.

In this application, there are four circuit-closers, *a*, *r*, *q*, O, in combination with one battery X, and three electro-magnets, G, T, and E, and the audible signal R, operated upon an open circuit upon the line of the railway. Of these circuit closers, *a* and O are for actuating the audible signal R; *r* and *q* are for stopping the same. Auxiliary batteries Y and Z are brought in combination with the visual signals A and B by circuit-closers H and N.

What I have here described was the construction and operation of the said application in 1871, and it employed only one double-circuit instrument, marked No. 3.

These applications, which are shown in Defendants' Exhibits 2, 4, and 9, were in progress of construction in the fall of 1872, when I became engaged in the work.

(Defendants' counsel put in evidence the diagram last referred to, which is marked Defendants' Exhibit No. 9, E. E. M., Exr, March 31, 1877.)

Int. 21. Look at the drawing I now show you, and tell what it is.

Ans. This drawing represents the same system as was shown in the model Exhibit No. 5. It is a parallel perspective, and working plans of this system as applied on the Eastern railroad in the winter of 1873–'4.

(Defendants' counsel placed in evidence the drawing last referred to, which is marked Defendants' Exhibit No. 10.)

235 Int. 22. State, if you know, who were in your father's employment in applying his electro-magnetic signal apparatus at Stamford, Conn., 1869.

Ans. Stephen C. Hendrickson.

Int. 23. State if there were others.

Ans. Yes, sir; there were a number of workmen; I recollect now only the names of two others, which were Everett and Lumb.

Int. 24. State whether or not you made any sketches of the signal apparatus of your father applied at Stamford, and the connections thereof, at the time you first saw it in the fall of 1869.

Ans. Yes, sir, I did.

Int. 25. For what purpose?

Ans. To become familiar with the system, as I was then a student at Yale scientific school, engaged in the study of physics, and gave Prof. Lyman a detailed description of the same, which he explained before the class.

Int. 26. Had you before that studied the subject of electricity, and if so, where?

Ans. Yes, sir, at Phillips Academy, Andover, Mass., where I took a two years' course, and also at Yale scientific school, being engaged at the time of the examination of the system of Stamford as a student of physics.

Int. 27. State whether or not your father gave you any explanation of the system that you put up in the shop at West Meriden, as shown in Exhibit No. 5, before he gave you instructions to put the same up, and if so, how long before?

Ans. He informed me, some six months before, that he was engaged in perfecting the system, which I put up under his supervision in December, 1872.

Int. 28. Have you personally superintended or worked at the application of your father's electro-magnetic signal apparatus in connection with railways, and if so, during what period, and on what railroad?

Ans. Yes, sir; I have been actively engaged both in the
236 constructing and supervision of my father's signals from the time that I left the employment of the Harlem R. R. in the

spring of 1872 until April 4th, 1876. I have been connected with the constructing and applying signals to the following roads: N. Y. Central & Hudson R. R. R.; N. Y., N. H. & H. R. R.; Eastern R. R.; Boston, Lowell & Nashua R. R.; Boston & Albany R. R., and the Old Colony R. R.

Int. 29. On what railroads beside these just mentioned has your father applied electro-magnetic signal apparatus?

Ans. Flushing & Northside R. R., and Morris & Essex R. R., and on the New Jersey R. R.

Int. 30. For how many years has your father been engaged in making and applying electric signal apparatus to railroads, and what proportion of his time has he given thereto?

Ans. From the date of his first patent, some eleven years, and he has given his whole time to it; he has not been engaged in other business.

Hearing adjourned to April 3, 1877, at 1 p. m.

237 NEW YORK, *April* 3, 1877.

The parties appearing as before.

Direct examination of Mr. A. H. HALL resumed:

The card which is attached to Exhibit No. 5 is a picture of Defendants' Exhibit No. 3. Defendants' Exhibit No. 3 was one of the circuit-closers put up in the shop, as before mentioned, in December, 1872. I was connected with the work of putting up the signal apparatus on the Eastern R. R., and Boston & Lowell R. R. under G. H. Snow, and took entire charge of the surveying and construction of the work on the Boston & Albany R. R. and the Old Colony R. R., making all the plans for the same. On the Boston & Albany R. R. I drew the plans and took entire charge of applying the signals for a distance of twenty-two miles of double track railroad.

On the Old Colony, I made the plans and superintended the construction of seven miles double track railroad.

Int. 31. Look at Mr. Pope's patent 140,536, and state whether you have examined the same and are familiar with the contents of the drawing accompanying the same.

Ans. Yes, sir; I have carefully examined the same.

Int. 32. State whether in your opinion this patent, with its specification, claims, and accompanying drawing, gives such a description of the invention which it purports to set forth, that a person skilled in the art of the application of electricity and electro-magnetism to railroad signalling would be able, from said patent and specification, claims and drawing, and without other aid, to construct an apparatus which would accomplish the object which said patent purports to describe, in the manner therein specified.

Ans. No, sir.

Int. 33. State your reasons.

Ans. First. The patent does not state how sections of track are to be insulated at points marked A, A1, A2, &c.

Second. The manner of combining the electro-magnets M, M1,

M2 (which actuate or display the respective signals) with said signals is not stated.

Third. The mode of retaining the signals in position
238 after they have been acted upon by electro-magnets M, M1, M2, is not stated.

Fourth. The term "said signals may be of any suitable construction," does not explain whether a local or secondary battery is employed in the mechanism of said signal, or whether it is operated by suitable mechanism.

Fifth. The manner of releasing the signals by electro-magnets M, M 1, M 2, is not explained.

Sixth. The mode of combining metallic conductors with electro-magnets and circuit-closers is not explained.

Int. 34. I will call your attention to the matter of the resistances of the different circuits. Is the specification definite and complete in that particular?

Ans. No, sir; the manner of adjusting the respective resistances of the several circuits is not explained.

Int. 35. Would it, in your judgment, be practicable to maintain such an apparatus as this patent purports to specify, in successful operation for any length of time, without securing a substantial equality of resistances in the different circuits?

Ans. No, sir; it is essential, in the operating of signals upon railroads, that the resistances of the several circuits be equalized; otherwise the circuit would be too weak to operate a signal at a remote point from the battery, and too intense to operate a signal at a point near the battery. In all cases the resistances of the several circuits must be nearly or quite equal. Mr. Pope recognizes this fact in the fifth clause of the specification, in which he says: "The respective resistances of the several circuits should be so adjusted that they will be as nearly as possible equal to each other."

Cross-examined by Mr. PERKINS:

Cross-int. 34. Referring to Exhibit No. 2, were not all the twelve double-circuit instruments and signals and batteries shown
239 in the exhibit, and referred to by you, located at one point on the road, so that they were all in view at one time?

Ans. No, sir; they were not. The visual signals were placed at one point on the railroad, and the audible signal was placed at a point on the line of the railroad remote from the visual signals.

Cross-int. 35. With the exception of the audible signals were they all located at one point, and in view at one time?

Ans. No, sir; the visual signals, for convenience, were placed in one large building with the double-circuit instruments and battery. No two signals were in view at the same time. The twelve visual signals being arranged to notify the switch-tender at a point remote from this building when it was desired to turn the switch from the main inward track on to any one of the twelve tracks which were in the Grand Central Depot, an audible signal was given to the switchman at this remote point.

A visual signal was at the same time given by displaying a num-

ber corresponding to the track on which it was desired to admit the train.

This visual signal would remain before the glass of the signal case until the switchman had turned his switch to the corresponding numbered track, when the switchman would remove the signal from sight by reversing circuit-closer placed in the switch-tender's shanty.

The combination of any one of these signals was threefold:

First, the sounding of the audible signal in the switch-tender's shanty was to inform him to turn a switch on to a particular track.

Second, the number of this track was made known to him by the displaying of its particular visual signal, each track having its respective visual signal, which was distinguished by a color and a number corresponding to its track.

Third, the moving of this signal from sight informed train dispatcher that his orders were obeyed.

240 As the switch on the main line could be turned on to only one of these twelve tracks at the same time, so no two visual signals could be displayed at the same time.

Cross-int. 36. Were these visual signals so displayed at or near the same spot?

Ans. I have before remarked that, for convenience, the twelve signals were placed in one large signal-house close together, and showed through two tiers of apertures, one above the other, and there being six apertures in each tier situated about one foot apart. There were two such tiers on each side of the building. Each signal so became visible through two apertures, one on each side of the building.

Cross-int. 37. Was not the sole object of the audible signal to call attention of the switchman to the fact that the train dispatcher desired him to look at the signal-house?

Ans. No; he desired him to move a switch, the number of which he informed him of by its corresponding visual signal.

Cross-int. 38. Could the switchman learn, from hearing the audible signal alone, to what track the train dispatcher desired him to move the switch?

Ans. No, sir.

Cross-int. 39. To learn that, then, he would be obliged, when he had heard the audible signal, to look at the signal-house, and find from the signal there displayed what the train dispatcher wished him to do?

Ans. Yes, sir.

Cross-int. 40. Were not all the raising keys shown in the diagram placed at one point in the train dispatcher's office so that he could exhibit any one of the signals at pleasure by depressing a corresponding circuit-closer key with his finger?

Ans. Yes, sir.

Cross-int. 41. Explain the manner in which the train dispatcher closed the circuits.

Ans. The twelve black dart-heads on the upper right and left hand corners of the diagram, unders numbers 1 to 12 inclu-

241 sive, represent keys which, when depressed, connect two me-

tallic conductors, proceeding from either pole of the battery, and so complete the circuits.

Cross-int. 42. Were not all the reversing keys in the switchman's shanty also so placed at one point, so that he could conceal any one of the signals, which had previously been raised by the train dispatcher by depressing the appropriate key?

Ans. Yes, sir.

Cross-int. 43. What was the distance between the points at which the raising keys were situated, and the building containing the double-circuit instruments, visual signals, and batteries, and also the distance between the latter and the place where the reversing keys were situated? State as nearly as you can.

Ans. The distance between the raising keys and the building containing the visual signals, &c., was about a thousand feet, and between the latter and the reversing keys about 1,500 feet.

Cross-int. 44. Could the train dispatcher learn whether the signal was displayed by his touching the key, or was concealed by the switchman in any other way than by looking to see?

Ans. No, sir.

Cross-int. 45. Was not the battery Y, which vitalized signal-magnet S^1, entirely distinct from the battery marked X, which was brought into action by the raising and reversing keys to actuate the double-circuit instruments?

Ans. The battery X was the battery employed in connection with twelve raising circuit-closers and twelve reversing circuit-closers, together with twenty-four magnets of the twelve double-circuit instruments, and the electro-magnet of the audible signal at the switchman's shanty, to operate the audible signal.

Battery Y was part of a suitable means of exposing and concealing the visual signals.

Battery Y, being a secondary battery employed for this purpose, it could not be brought into action without the other.

242 Cross-int. 46. Is not, then, the double-circuit instrument, in fact, what is usually known as a relay, for bringing into action a secondary battery for operating the signal, with the addition of a device for maintaining the said relay in act ionafter the primary or key circuit is broken?

Ans. Yes, sir. The double-circuit instrument is, in fact, a relay instrument, by which the secondary signal is operated upon by a secondary circuit-closer and its secondary battery, this being a suitable means provided for retaining and concealing the signals, after the circuits through the primary magnets of the double-circuit instruments have been interrupted.

Cross-int. 47. When was this apparatus described in Defendants' Exhibit 2, erected at the Grand Central Depot, so as to be in working order?

Ans. In December, 1871, or January, 1872.

Cross-int. 48. How long did it remain there, in active operation?

Ans. Until the improvements which were made in sinking the approach to the Grand Central Depot necessitated its removal. I do not know the date.

Cross-int. 49. Can you tell approximately how long it remained in active working order, after it was set up, as you have described?

Ans. The erection of the bridge, immediately in rear of the Grand Central Depot, hid from sight the signals contained therein from the train dispatcher, when the use of this code of signals was abandoned—I think in the summer of 1875—the signals having been in operation about 3½ years.

Cross-int. 50. Was this apparatus erected under any letters patent granted to your father; and, if so, when granted?

Ans. By the terms of his contract with the Harlem R. R. Co. he granted to them the right to use any and all patents which were then granted to him, and also any and all patents which might thereafter be granted to him, pertaining to signals on railroads.

243 This apparatus was covered by the following patents granted to him, viz:

Letters patent		No. 97,505,	dated	Dec. 7, 1869.
"	"	No. 62,414,	"	Feb. 26, 1867.
Reissued	"	No. 3,859,	"	M'ch 1, 1870.
"	"	No. 103,174,	"	May 17, 1870.
"	"	No. 103,875,	"	June 7, 1870.
"	"	No. 105,447,	"	July 19, 1870.
"	"	No. 113,425,	"	Apr. 4, 1871.
"	"	No. 97,505,	"	Dec. 7, 1869.
Reissued	"	No. 4,493,	"	Aug. 1, 1871.
"	"	No. 118,606,	"	Aug. 29, 1871.

Cross-int. 51. Referring to Exhibit 1 A, state whether that apparatus was covered by letters patent granted to your father; if so, what and when granted?

Ans. Yes, sir, by

letters patent		No. 97,505,	dated	Dec. 7, 1869.
"	"	No. 103,875,	"	June 7, 1870.
"	"	No. 103,174,	"	May 17, 1870.
"	"	No. 105,447,	"	July 19, 1870.

Hearing adjourned to April 4, 1877, at 10 o'clock a. m.

244 NEW YORK, *April 4th*, 1877.

Cross-examination of A. W. HALL resumed.

Witness desires to state, in addition to his answers to cross-int. 51, that—Some of the instruments, that I saw at Stamford in the fall of 1869, in actual use, were not patented until 1870.

Cross-int. 52. State whether the apparatus described in the diagram, Exhibit 4, was covered by patents issued to your father; and also that described in Exhibit 9.

Ans. Yes, sir; they were, both of them.

Cross-int. 53. Referring to Exhibit 4, state how many stations for signals, and how many batteries, there were between the Grand Central Depot and Mott Haven, in the whole distance, without regard to those shown on said exhibit.

Ans. I do not now recall the number, but I should say about twenty signals, each signal having its respective battery.

Cross-int. 54. When was the apparatus described in Exhibit 9 completed and put in actual operation?

Ans. At about the same time, [within a few days,] that the signals shown by Exhibit 2 were put in operation; about December, 1871, or January, 1872.

Cross-int. 55. Referring to Exhibit 10, state when the apparatus described therein was completed upon the Eastern railroad, so as to be practically used?

Ans. This application was never practically used. The arrangement of the main wires A and B, in connection with a galvanic battery, circuit-closers, and electro-magnets, as shown in this Exhibit No. 10, proved an utter failure. This practical demonstration was arrived at in the winter of 1873–4, I think in January, 1874.

Cross-int. 56. When did you commence the construction
245 of this apparatus upon the line of the road? State as nearly as you can, and state what you did in its construction, and at what point you stopped?

Ans. The construction of this work was begun at once, after my father had received an order from C. F. Hatch, the general manager of the Eastern railroad, to reconstruct the electric signals on the said road according to the plan shown in Exhibit 10, which order was received early in the spring of 1873. The work was begun at once, after this order was received, at the shops of my father, at West Meriden, Conn. As soon as the instruments were completed they were applied between Salem and Lynn, on the line of the Eastern railroad, commencing at Salem and ending at Lynn, a distance of five miles, embracing in all about thirty-five signals, inclusive of those at Salem and Lynn. This work was begun in November, 1873. The signals between Salem and Lynn were operated by one battery at Salem, and it was our intention to establish another battery at Chelsea to operate the signals between Lynn and Boston, a distance of twelve miles; but after having connected the signals between Salem and Lynn with the battery at Salem, and having proved this system a failure, we were obliged to adopt the arrangement of wires in connection with a battery, as shown in Exhibit No. 8. The section of signals between Salem and Lynn, in connection with the battery at Salem, was changed to this latter plan February 14th, 1874. This latter plan having proved a success by the perfect working of its signals between Salem and Lynn, the system was then applied between Lynn and Boston, the battery for these signals being placed at Chelsea.

Cross-int. 57. Where was the interview you have mentioned between your father and Mr. Hatch, in which this order mentioned in your last answer was given; and were you present thereat?

Ans. I accompanied my father to Boston, and went with him to Mr. Hatch's office, in the depot of the Eastern R. R. in Boston, at which time my father explained to Mr. Hatch the system
246 shown in Exhibit No. 10, my father having suitable drawings of the same, and at which time Mr. Hatch gave him the said order.

Cross-int. 58. State the date of this interview as accurately as you can, and state whether you have any means by which you may determine it with precision?

Ans. It was the last of February or first of March, 1873. I have no means of determining the precise date.

Cross-int. 59. By what means do you fix the date as being the last of February or first of March?

Ans. Having been called to West Meriden, Conn., by a letter received from my father, in which he desired me to come to Meriden at once, I being at that time in Boston. Said letter I received the latter part of December, 1872. Upon my arrival in Meriden, I put up, under the direction of my father, instruments in his shop, as shown in Exhibits Nos. 5 and 6. I remained in Meriden at this time some three weeks, making the date of my return to Boston about the 15th of January, 1873. It was then about four weeks from the date of my return to Boston when I again went to Meriden, Conn., to confer with my father in regard to this improvement. To the best of my recollection, I remained in West Meriden at this time some two weeks, and then went on with him and had the interview with Mr. Hatch before referred to.

By following this succession of events I am confident that I cannot be two weeks out of the way in my statement of the date of the interview. I don't pretend to give these dates nearer than that.

Cross-int. 60. Do you know who prepared the drawings, which you say your father showed to Mr. Hatch, at his office in the Eastern R. R. depot, and what has become of the same?

Ans. I prepared the drawings at the time I was in Meriden putting up the instruments, as shown in Exhibits Nos. 5 and 6. I am not aware what has become of them.

Cross-int. 61. When and where did you last see them?

Ans. I do not recollect what became of the drawings
247 after they were exhibited to Mr. Hatch, that being the last time that I can recollect seeing them.

Cross-int. 62. In the erection of the apparatus described in Exhibit No. 10, if I understand you correctly, you first substituted for the signal apparatus then existing nearest Salem, which was working under the former plan of your father, a signal apparatus made in conformity to one of those shown in Exhibit No. 10; and then substituted signal apparatus, as they were completed, one at a time, all along the line between Salem and Lynn; is this so; if not, state how you proceeded?

Ans. No, sir; in the arrangement of this system two wires, A and B, were attached to the positive and negative poles respectively of the battery X; these wires being continuous wires from the battery to the last signal of the system of signals between Salem and Lynn. To use the wires that were at the time used in the existing system, it became necessary to connect them with each other, so that the detached sections were united into two continuous lines. This preventing the working of the existing signals, an order was issued by the general manager of the Eastern railroad, to discontinue the use of the signals between Salem and Lynn, till such time

as the signals should be reconstructed for the whole distance between these points. All the instruments were then changed to conform with the system shown in Exhibit No. 10, and when said new system of apparatus was completed, the battery at Salem was connected with the wires A and B, and each signal connected with branches of said wires respectively. The system of signals between Salem and Lynn was thus put in operation as a whole, at one time.

Cross-int 63. Will you describe the track circuit-closer, in use on the Eastern railroad before the system shown in Exhibit No. 10 was placed upon the road?

Ans. I will prepare a diagram from which to describe the same, and introduce it hereafter.

Cross-int 64. Describe the battery X actually used at Salem
248 in the winter of 1873–4, which, you say, destroyed the circuit-closers; giving the numbers of cells, &c., sufficiently to show its power and mode of operation?

Ans. The battery which we then used at Salem was what is termed an electro-poion battery, of some sixty cups or cells, the size of the cells being what are termed in the trade No. 2 cells.

Cross-int. 65. Was the same battery used after the apparatus was modified, as shown in Exhibit No. 8, which you say was put in operation February 14th, 1874; and, if not, state what was used?

Ans. No, sir; the gravity battery was substituted for convenience; the latter being a more constant battery, it is found for telegraphing purposes to be superior to the electro-poion battery. This gravity battery being less in intensity than the electro-poion battery, per cell, a sufficiently greater number of cells were added to make the intensity of the gravity battery equal to that of the electro-poion battery of sixty cells. The circuit, which was completed from the battery and circuit-closer of signal 1 A, as shown in Exhibit No. 10 (said signal being at the remote end of the line at Lynn), was exactly equal to the circuit which was completed from the battery and circuit-closer of signal 1 A, as shown in Exhibit No. 8 (said signal being at the remote end of the line at Linn).

Cross-int. 66. Did the electro-poion battery, when put in operation, actuate the visual signal 1 A, being the one most remote from the battery, as shown on Exhibit No. 10?

Ans. Yes, sir; the number of cells of which the battery was composed being determined by the number requisite to operate the most distant signal.

Cross-int. 67. What kind of wires were used in the arrangement shown in Exhibit No. 10, and therein marked main wires A and B.

Ans. Washburn & Moen's galvanized No. 9 wires.

Cross-int. 68. Who were employed in setting up the signal apparatus between Salem and Lynn, as shown in Exhibit No.
249 10, and who conducted the experiments with the electro-poion battery, which you say resulted unsuccessfully?

Ans. As I have before stated, George H. Snow superintended the construction of this line; I was engaged with him; also William Everett, and a number of workmen who were furnished us by the Eastern R. R. Co., as we desired them, and whom we obtained by

requisition on the master carpenter of the Eastern R. R. Co., Mr. Ingalls; the names of some of whom were Cass, Ingalls, and Sullivan. The names of the others I do not recollect. Mr. Snow conducted the experiments, and I was familiar with the progress and results produced from day to day.

Cross-int. 69. Was the system of signals existing on the Eastern R. R. before you applied the system shown in Exhibit No. 10 the same as that which you have hereinbefore described as existing on the Harlem R. R. between the Grand Central Depot and Mott Haven, and shown in Exhibit No. 4; and, if not, state the difference?

Ans. Yes, sir; it was the same.

Cross-int. 70. Have you prepared the diagram referred to in your answer to cross-int. 63; and, if so, will you describe it?

Ans. I have had prepared such a diagram, and will describe it; a lever A B is placed at right angles with the tracks, and with the short end near the track. This short end projects above the level of the top of the rail, three-eighths of an inch. The fulcrum of this lever is at C, and the wheel D of the train, depressing this short end as it passes along the rail E, throws up the long arm of the lever B, which raises the metallic spindle F; said spindle making contact at its upper end with the metallic conductors G and G^1, with which the wires H and H^1 are connected at one end, the other ends of the wires being connected with opposite poles of the battery by an intermediate magnet. After the wheel has passed over the lever A the lever returns to its former condition, and the spindle F is forced down by the spring J pressing against its cross-bars K and K^1.

250 The mechanism of the spindle and its connections is protected from the weather by the suitable cap L. M is a rubber spring, against which the short end of the lever, A B, is depressed, when struck by the wheel; the operative effect of which is to break the force of the blow of the wheel when it strikes the lever, and also to return the lever, when the wheel has passed, to the desired elevation above the track. This operation is performed by each successive wheel of the train, while passing.

(Complainants' counsel offer in evidence the diagram produced by the witness, which is marked Complainants' Exhibit D, E. E. M., Ex'r, April 4, 1874.)

Cross-int. 71. How long were you occupied in erecting and constructing the aparatus at West Meriden, shown in Exhibits Nos. 5 and 6?

Ans. In all about a week.

Cross-int. 72. Did any one assist you; and, if so, who?

Ans. No, sir.

Cross-int. 73. What kind and size of battery did you use in the aparatus as put up?

Ans. Three cups of No. 2, electro-poion.

Cross-int. 74. Was this a battery that you had on hand, or one that was made for the purpose?

Ans. One that we had on hand; the electro-poion battery being

the most desirable, for the reason that an intense current can be generated the instant that it is put up.

Cross-int. 75. What kind and size of wire did you use?

Ans. Office wire; a kind of wire used for experiments with electricity.

Cross-int. 76. Were the double-circuit instruments used, all on hand; and, if so, how long had they been made, as near as you can tell?

Ans. They were all on hand; I could not state how long they had been made; they were part of our stock in trade which we kept on hand all the time.

251 Cross-int. 77. What kind of circuit-closers did you use in putting up this apparatus?

Ans. What we term hand circuit-closers, which are described in letters patent No. 118,606, dated August 29, 1871, granted to my father, and depicted in sheet No. 8 of the drawings accompanying that patent.

Cross-int. 78. Could these circuit-closers be used in the actual operation of this signal apparatus when placed upon a railroad?

Ans. Yes, sir; they are so used when it is desired to operate a signal by hand.

Cross-int. 79. Did you use such circuit-closers when you placed this signal apparatus on the Eastern R. R.?

Ans. Yes, sir; at all points where it was desired to operate a signal by hand, they being placed at all stations on the Eastern R. R. to give station agents control over the signals to which they were connected.

Cross-int. 80. Could such circuit-closers be used for actuating the automatic signals, as shown in Exhibit No. 10, so as to be affected by passing trans?

Ans. These circuit-closers were placed, for convenience, on the wall of the shop of my father, instead of placing the large-sized circuit-closers in the building. In fact, one of these circuit-closing points, marked Y in Exhibits Nos. 5 and 6, was connected with a track circuit-closer situated on the down track of the N. Y., N. H. & H. R. R., at a point an eighth of a mile from the building, wires having been run on telegraph poles from this building to the railroad; and all down trains on said road would close the circuit-closer placed in proximity to the rail, causing a circuit to be completed from battery X, by wires A and A 1, to circuit-closer placed in proximity to the railroad (by a wire provided for that purpose), through that circuit-closer to an electro-magnet, Z, by a wire provided for that purpose, and wire *b* 1 of double-circuit instrument No. 1, through said magnet to battery, by wires B 1 and B.

252 In fact, the circuit-closing point of double-circuit magnet Z of double-circuit instrument No. 1 was removed to a point on the line of said railroad by prolongation of wires A 1 and *b* 1.

The balance of the circuit-closers were what we term hand circuit instruments, and were intended to illustrate the closing of circuits by trains operating upon their proper circuit-closers.

In fact, the erection of this apparatus upon the side of the building was a perfect working model of our signals, as shown in Exhibit No. 10.

Our regular double-circuit instruments (such as we used in the application of our signals) were used. One of our regular track circuit closing instruments (such as we used in the application of our signals) was used, together with eight of our regular hand circuit instruments (such as were used in the application of our signals.) There were also three cups of an electro-poion battery used, together with a quantity of office wire necessary to run the wires from the side of the building, as shown in Exhibits Nos. 5 and 6, and also a sufficient quantity of galvanized telegraph wire No. 9, to connect wires A 1 and *b* 1 with a track circuit-closer placed in proximity to the down track of the N. Y., N. H. & H. R. R.

(Counsel for the complainants objects to the foregoing answer, as not responsive to the question.)

Cross-int. 81. In your answer to int. 12, you say it became necessary to manufacture an entire new set of track circuit-closers; were these different from the track circuit-closers used on the Eastern railroad theretofore; and, if so, how did they differ?

Ans. Yes, sir; they were different. They were the circuit-closers for railroad signals for which letters patent were granted to G. H. Snow, No. 143,935, dated October 21, 1873.

(Complainants' counsel offers in evidence the above-named letters patent, which are marked Complainants' Exhibit E, E. E. M., Ex'r, April 4, 1877.)

253 Cross-int. 82. State why it became necessary to substitute these last-described circuit-closers in place of those previously used on the Eastern railroad in the former system of signals.

Ans. In the application of signals, as shown in Exhibit No. 10, it became necessary that the electric circuits which were established through the track circuit-closers should be established for a longer time than was previously required by the former system of signals. To produce this result, a track circuit-closer, as shown in Exhibit E, was invented.

(Hearing adjourned to April 5th, at 10 a. m.)

NEW YORK, *April 5th*, 1877.

Cross-examination of A. W. HALL continued.

Cross-int. 82*a*. What, if any, alterations had to be made in the visual signal instruments on the Eastern R. R., theretofore existing, to adapt them for use in the plan shown in Exhibit No. 10?

Ans. In the former system the signal was displayed and held in this position so long as a circuit was established from a battery, through circuit-closer C of Exhibit No. 3, and electro-magnet A, as shown in Fig. 2 of letters patent 103,875, dated June 7th, 1870, issued to my father. In the latter system, as shown in Exhibit No. 10, a signal was displayed so long as a circuit was established from

the battery at Salem, through a track circuit-closer (which was connected with its corresponding signal) and electro-magnet A, as shown in the drawing which I here present.

(Complainants' counsel put in evidence the above-mentioned patent and drawing, which are marked respectively Complainants' Exhibits F and G, E. E. M., Ex'r, April 5, 1877.)

254 In the system as first applied on the Eastern R. R., the signal was displayed and held in this position by the armature E of electro-magnet A, shown in Exhibit F, drawing No. 2, being attracted to said magnet, and being held in this position so long as the signal was displayed.

The effect of this armature being attracted to its magnet by a constant current of electricity passing through said magnet A was to display the signal and keep it in this position so long as said current lasted.

The said current being established from a battery, and circuit-closer C of Exhibit No. 3, and electro-magnet A of drawing No. 2 of Exhibit F, when the circuit was broken by circuit-closer C of Exhibit No. 3, the signal, as shown in Fig. 2 of Exhibit F, would fall out of sight, by gravitation.

The circuit being broken, the action of electro-magnet A, in attracting its armature E, as shown in said Fig. 2 would cease. In the system of signals, as shown in Exhibit No. 10, the signal was displayed and kept in this position by the momentary closing of a circuit-closer by a passing train.

A circuit being established from the battery at Salem, and a track circuit-closer through electro-magnet A of Exhibit G, that magnet would attract its armature and display the signal.

The attraction of this armature brings into action a spring catch B, as shown on Exhibit G, which would hold the signal displayed, by this mechanical means, until a train had again operated upon this signal and established an electric circuit from the battery at Salem and another track circuit-closer through electro-magnet C of Exhibit G. The completion of this circuit vitalizes electro-magnet C, and it attracts its armature and removes the spring catch B from the armature of electro-magnet A, thus allowing the signal to fall by gravitation.

The difference in the displaying of these visual signals on the Eastern R. R. was that, in the former plan, the signal was dis-
255 played by a continuous circuit being established through its magnet, and in the latter plan, as shown in Exhibit No. 10, the signal was displayed by the momentary completion of a circuit through its magnet, and the use of the spring catch B of Exhibit G.

Cross-int. 83. Was this the only difference between the visual signal instruments?

Ans. This was the only difference, except when it was desired to operate another visual or audible signal from the signal as shown in Exhibit G, when a circuit-closer D was applied to this signal, for momentarily closing a circuit by the arm E of the signal.

Cross-int. 84. In your answer to int. 11 you say that your father

showed the application represented in Exhibits No. 5 and 6 to a number of persons. State to whom and when it was so shown.

Ans. As soon as this device was completed, he showed it to Station Agent Stoddard, of Meriden, Conn.; Mr. E. M. Reed, superintendent of the N. Y., N. H. & H. R. R.; to Mr. Pressy, of Stamford, Conn., supervisor of said road; Dr. Wilson, Charles Parker, Dexter W. Parker, O. H. Platt, all of Meriden, Conn.

Cross-int. 85. Did these persons see this device in actual operation when so shown to them?

Ans. Yes, sir; they did.

Cross-int. 86. In your answer to the same question, you speak of your father's delight in overcoming the difficulty of requiring a battery for each signal. Was that a serious practical difficulty in the system of signals used by your father before that time?

Ans. Yes, sir; it was. The very fact of performing the same work, on the Eastern railroad, with 400 cells of battery, by this improvement, in the place of 3,000 cells which were necessary in the former system, overcame one important objection.

Cross-int. 87. In your answer to int. 33, you say that Pope's patent is insufficient in not properly explaining the mode of com-
256 bining the metallic conductors with electro-magnets and circuit-closers. State more in detail to what defect you refer.

Ans. I mean to say that a person skilled in the art of applying electric signals to railroads could not, from the details furnished in Mr. Pope's patent, be able to make metallic conductors, with circuit-closers and magnets, without further instructions in regard to the same.

Cross-int. 88. Does not the drawing annexed to said patent show that the metallic conductors, magnets, and track circuit-closers are connected by branch wires, which are referred to by corresponding numbers in the specification?

Ans. Yes, sir; but not sufficiently in detail, in my opinion.

Cross-int. 89. Is your objection, then, that the specification does not detail the precise method of annexing these branch wires to the metallic conductors, magnets, and track circuit-closers?

Ans. Yes, sir.

Re-examination by Mr. BALDWIN:

R. E. Int. 90. I call your attention to the construction of the rod F, connected with the armature lever in Exhibit G. Was there any difference in the construction of that rod and the means formerly employed to raise the signal?

Ans. I should have said, in my answer to cross-int. 83, that this rod was changed from a stiff rod in the former plan to a compensating rod, which contained a spring, at point G in Exhibit G; the object of this change being explained in patent No. 150,030, dated April 21, 1874, issued to my father; Fig. 7 of the drawing accompanying which indicates the construction of the rod in question.

(Defendants' counsel put in evidence the patent last referred to, which is marked Defendants' Exhibit No. 11, E. E. M., Ex'r, April 5th, 1877.)

257 R. E. Int. 91. In your answer to int. 10 you stated that no signals were operated from the apparatus you put up in the shop in Meriden, in the winter of 1872–1873, described in Exhibits Nos. 5 and 6, at the time you put the same up.

State whether, subsequently to that time, you made any use of such apparatus at your shop, in connection with any railroad track, for actuating automatic signals.

Ans. Yes, sir.

R. E. Int. 92. When and how?

Ans. In March or April, 1873. The manner of the application is described in my answer to cross-int. 80, to which I therefore refer you, in order to avoid unnecessary repetition. I will add, however, to what is therein contained, that, in connection with this track circuit-closer therein mentioned, the visual signal, as shown in Exhibit G, was substituted in the place of one of the five double-circuit instruments which were in the circuit of battery X, as shown in Exhibit C.

R. E. Int. 93. In your cross-examination, the term *relay* was used by Mr. Perkins. What is commonly known by the term "relay instrument"? Describe its principal constituent parts.

Ans. It consists of a magnet and its armature in the circuit, with its battery and connecting wires.

R. E. Int. 94. What is the proper and usual function of a relay?

Ans. It is used in connection with a primary battery, when the current from said battery is too weak to produce the desired effect, but is strong enough to bring into action a second electro-magnet and its armature, in a circuit with its own battery and connecting wires; such latter circuit being the relay or local circuit.

R. E. Int. 95. You have stated in your answer to cross-int. 46 certain points of similarity between Exhibit No. 3, [or your father's double-circuit instrument,] and the relay. State the differences, if any, between said instrument and what is usually known as a relay.

258 Ans. In this double circuit instrument the second established circuit does not aid in any way the primary circuit in the performing of its respective functions.

In the double-circuit instruments a locking-lever, which is described in Fig. 1 of reissue 4493, dated Aug. 1, 1871, of patent 97,505, dated Dec. 7, 1869, to my father, and which is therein marked F, is applied in combination with the armature-lever C of an electro-magnet—said armature-lever serving to actuate a signal, or to close a circuit through another electro-magnet, or to produce another effect whenever the circuit through the first electro-magnet is closed—in such a manner that, by the locking-lever, the armature-lever of the first electro-magnet is retained in position, after the circuit through said electro-magnet has been opened, and the effect produced by said armature-lever is continued, until the same is released by the locking-lever or stop. Without going into detail the principal differences are: First. In the relay instrument the function of the primary battery is merely to bring into action a secondary battery or relay battery. It exhausts itself in this operation, bringing

in the aid of the secondary battery and its magnet to complete the work it is too weak to accomplish itself. In the double-circuit instrument the armature-lever C of the electro-magnet is attached to a visual signal, which remains displayed so long as the retaining lever holds the armature-lever in position; or this result may be produced by bringing into action a second battery, whose function is entirely distinct from the former battery.

The battery, which actuates the armature-lever C does not depend upon the secondary battery to aid it in performing its work.

The combination of circuit-closer C with the secondary battery is merely a proper mechanical means employed for displaying the signal.

Hearing adjourned to April 16, 1877, 1 o'clock p. m.

259 NEW YORK, *June 6th*, 1877.

Evidence continued by consent in lieu of April 16th, 1877, Mr. Hall appearing for complainants, and Mr. Baldwin for defendant [The evidence of Alvah W. Hall is to be resumed when Mr. Perkins is present.]

GEO. H. SNOW, a witness produced by the defendant, sworn, and examined by Mr. BALDWIN:

My name is Geo. H. Snow; residence is West Meriden, Conn.; age is 39 years, and my present occupation is in the employ of the Hall Railway Signal Company as machinist. I first became acquainted with Mr. Thomas S. Hall some time in May, 1870. I was then living in New Haven, Conn., and was then engaged in the business of carrying on a small machine-shop in company with Geo. H. Coe. We were making special machinery and tools, and jobbing generally. I had at that time no especial acquaintance with electric machinery or electric engineering; that had been no part of my business up to that time. Mr. Hall came to my shop and wanted to know if I could make his instruments some time in May, 1870. His idea was to know if I could make his electrical instruments of all kinds, and the tools for making the instruments; and soon after, within a few days of his first coming to see me, I went to work making his machines and the tools for making these machines. I went to Stamford within two or three days, after seeing him the first time, to look at his apparatus.

Exhibit No. 1 represents correctly his apparatus that I then saw at Stamford. I then looked at it sufficiently to understand the general principle of the apparatus, but not the details.

I was there several times afterwards from May, 1870, during the succeeding summer and fall, for the purpose of working upon
260 the signals, and understanding them, and making some changes. I had a pass on the N. Y. & H. N. R. R. for the purpose of fixing the signals at Stamford, from the first of July to the end of that year. Some of these passes, probably most of them, Mr. Hall procured for me, and all were procured for the sole purpose of putting up Hall's signals. I commenced giving my entire

time to the companies represented by Mr. Hall in the signal business, the 6th of May, 1871, and since said time, when employed at all, I have attended to his business, or the business of the companies which he has represented. It has, during that period, occupied my whole time, unless, perhaps a week or two, on vacation. From May, 1870, to May, 1871, I gave attention enough to Hall's business to superintend what work Hall ordered made and keep it going. I had other work, and it would be difficult to tell the proportion of time I gave to his business. The first work I did for him out of New Haven, other than that mentioned at Stamford, was to put up signals on the Hartford & N. H. R. R. at crossings; one at Park street crossing and one at Wethersfield crossing, near Hartford; two at Meriden, and one at Wallingford; this was in the winter of 1870–1871. I also made some applications of signals on the Flushing R. R. on Long Island. This was about the same time of these on the Hartford & N. H. R. R. The next one that I applied was on the Hudson R. R. R., in the spring of 1871, and was a crossing signal at Tarrytown. The next was on the N. Y. & Harlem R. R.

(Exhibits Nos. 4 and 9 shown to the witness.) This diagram represents the application of the Hall signals to the Harlem R. R., as made in 1871 and 1872. I was there all the time the application was being made. This application was made from the Grand Central Depot to and and including Mott Haven Junction. This diagram does not represent the whole line clear out there; it represents the plan of making the application. The next application which was made under my oversight was on the Eastern R. R., Mass., between Boston and Salem, and was com-
261 menced in the summer of 1872. Before this, however, I knew something of the system of switch signals put up in the Grand Central Depot. Part of the application to the Harlem R. R. consisted in arranging a number of them in such a manner as to give the train dispatcher control over the movement of the switches to open and close the main line of road to the different tracks leading into the depot. Exhibit No. 2 correctly represents the manner of connecting the signals together in a general arrangement, as they were in a building between 46th and 47th streets, near the Grand Central Depot.

I first heard Mr. Hall speak of the possibility of operating a long string of signals, by a single battery, about the first of 1873, at New Haven, Ct. This is the first I definitely recollect about it at the present time. The conversation which I refer to took place in Hall's signal shop, corner of Whitney avenue and Howard street, and, as near as I recollect, he said he could work the signals all the way from New York to Boston with one battery. Some time in April, 1873, we moved this shop and tools to Meriden, and had no shop in New Haven after that time. After we moved to Meriden, the first job we had away from the shop in setting up apparatus was to set up models of our signal apparatus in the depot of the Boston and Lowell R. R., at Boston, Mass. Down to this time and after April, 1873, at the shop in Meriden, we were employed in making a change in the signal instruments. The changes made were these: We

made a new track circuit-closer and the tools for making the same; also, a change in the signal whereby it could be operated by a momentary current instead of a continuous current, as we had previously done. When a signal was brought into its displayed condition by a momentary current, it was held in that position by a detaining lever.

Previous to that time the signal had been held in its displayed condition by continuous current of electricity passing through its magnet. All the change we made in the leverage of the sig-
262 nals was the adding of the above-mentioned detaining lever to hold the signal in position, which was in fact no change of the leverage.

To further decrease the time necessary to hold the circuit closed the connection between two of the levers on the signal was made in such a manner that a spring formed part of it. This spring was strong enough to hold the signal when displayed, and also to throw it into position. When the current was momentarily sent through the magnet it caused this spring to be suddenly compressed, which allowed the above-mentioned detaining lever to be brought into its position of holding the signal displayed; the spring then, expanding, would bring the signal in its displayed or raised position; whereas without this spring the circuit would have to be kept closed through the magnet until the inertia of the signal disc was overcome, and time allowed for its body to move through the required space.

There was an experimental application of these changes made on the railroad in Meriden; I think in April, 1873. (Exhibits Nos. 5 and 6 shown witness.) These exhibits represent the plan upon which Hall intended to work his signals with one battery for any distance.

I saw machines put up in the shop at Meriden upon the model represented by them. As near as I can remember the first that I saw was, I think, in January, 1873, soon after my return from work on the Eastern R. R. It was in the new shop in Meriden, which was then being built, and was roofed in and nearly completed. I saw what this model represents. I saw there wires fastened on the sides of the walls and connected with instruments and a battery in such a manner as to illustrate Mr. Hall's idea of working a number of signals with one battery. I cannot tell who showed it to me, or what called my attention to it. I might have seen it myself. (The witness is shown Ex. 6, and is asked to explain from it the operation of the apparatus referred to by the use of letters and figures on the diagram.)

X represents a battery; A and B represent two wires ex-
263 tending the length of the room, which was about 50 feet; wire A was connected at one end with one pole of the battery, and one end of wire B with the other pole; the extreme ends of these wires being open, by which I mean free or disconnected. Figures 1, 2, 3, 4, and 5 represent double-circuit instruments, like Exhibit C, and of the same size, which is full-sized instruments; by which I mean the full size that is used in practical signaling.

These instruments were to represent signals themselves, as they

used the momentary current, which it was thought necessary to use in working a number of signals on an open circuit by one and the same battery.

I was present when Alvah W. Hall explained the working of this apparatus, as given on pages 8, 9, and 10 of the defendants' testimony in this case, and I heard his explanation of its working, and say that it was correct. This apparatus remained in the shop at West Meriden some time, and some of it is there now. I went to work making the application of Hall's signals on the Eastern R. R. the 20th day of May, 1872; I think I went then to apply the signals from Boston to Salem; I first made a drawing of the signal houses, and showed the carpenters of the R. R. Co. how to build them; I was there on and off until about the 20th of January, 1873, the next year; I then received a telegram from Mr. Hall, at Meriden or New Haven, to come home, which I did.

When I arrived at home I went to work making these improvements, which I have described, drawing, planning, and experimenting. The object of said work, in part, was for the purpose of making such changes as would enable us to work a number of signals with one battery; I remained at home thus employed until the following fall, when I went to Boston in connection with putting up the models in the Boston & Lowell depot. This was in November, 1873. The apparatus which I then put up was designed to show the working of the signals by one battery, when the railroad was divided into blocks and sections, and the applications to switches, etc., as it had previously been done with a number of batteries. The design of
264 setting up this apparatus was to make a kind of public exhibition to railroad men of the working of this apparatus. Circular invitations were issued to railroad men to attend and inspect the same.

Defendants' counsel placed in evidence circular and ticket marked respectively Exhibits 12 and 13, E. E. M., ex'r, June 7th, 1877.

These were some of the circulars and tickets issued and used at that time. The exhibition referred to in these circulars, appointed for November 20th, 1873, did not take place. Mr. Hall was taken sick before that date, and for that reason it was not held. There was nothing done especially in the way of showing it off. I do not know that any one came to see it or saw it except the men working with me; one of these men was William Everitt. I do not recall any other name. Soon after the day when this exhibition was appointed and given up, I returned to Meriden and remained a few days, making drawings and a perspective view showing a railroad and signals applied, and then I was designing to make a visit west, to Michigan, and I went first to Boston from Meriden and saw Mr. Hatch, general manager of the Eastern railroad, and showed him the models in the Lowell depot, and explained the workings of the apparatus to him, after which I went to Michigan. I think I had arrived in Michigan by Thanksgiving day. I got to Boston from Michigan the 11th day of December, 1873, and saw there again Mr.

Hatch, and then went to work getting ready to change the signals over on the Eastern railroad to the one-battery plan.

When I showed the signals to Mr. Hatch at one of my said interviews with him, he called in two or more telegraph men to see if what I told him was right, I suppose. This interview being at the Lowell depot, where the models were and the men called in were; I think one of them was H. N. Rowell, superintendent of telegraph on the Eastern railroad, and the other a superintendent of con-
265 struction of the Western Union Telegraph Company, whose name I do not recollect, and I explained to them how the line was constructed in connection with the signals, etc., to give them as clear an idea as possible of its manner of working. I went immediately to work there, and staid there on the Eastern R. R. eight months, engaged in changing the system to the one-battery plan.

I was able, in making these changes, to save about three-quarters of a mile of wire to each mile. In the former system each block of signals was worked by batteries belonging to the block, and the batteries were contained in a house on the top of which the danger signal was placed, and to work the safety signal, which was placed six hundred or more feet distant, required to wires to connect its battery to the signal-house. In the new system, the safety signal being connected directly with the line wires, made such a change in the connection as to do away with the necessity of the two wires.

Exhibit No. 10 was shown to the witness, and an explanation asked.

It shows the application of a number of signals to a railroad, to be worked by one and the same battery, in the manner that we have been talking about. This represents the application of signals to the Eastern R. R. in the latter part of 1873, and the first part of 1874.

This plan shows battery X, from each pole of which a wire extends down the line as far as the signals are applied, where the end opens free. These wires are designated main wire A, and the other main wire B.

From each of these wires, branch wires were connected, leading to the different signals, where they were properly connected to the signals, as will be described.

On this exhibit is represented a parallel perspective view of a double track railroad with the signals applied, representing mile-blocks on each track. On the further track is represented three mile-blocks, designated mile-block No. 1, mile-block No. 3,
266 and mile-block No. 5, and on the nearer track is shown two mile-blocks, marked mile-block No. 2 and mile-block No. 4. Arrows on the track, or between the tracks, represent the direction in which the trains run.

This perspective view shows the signal cases and track circuit-closers, arranged in their respective order. What is here called a mile-block consists of what may be called a group of signals, as there are virtually two instruments, one of which is placed at the com-

mencement of a section of track which the block covers, and when operated by the train shows a red signal or signal of danger. As this is put in operation immediately upon the train's entering the section, and as the engine driver could not look back, after his train had passed a red signal, to see if the red signal was set in the rear of his train, therefore to enable him to know whether his train is protected or not, a secondary signal is placed about a thousand feet in advance of the danger or red signal; this signal may have a blue color, and its normal condition shows said color, but, by the displaying of the red signal, the blue one is concealed from sight.

The engine driver, by seeing that the blue signal is thus concealed after the length of his train had passed the red signal, would thus know that the rear of his train was protected from a following train. The further description will be shown from the plan drawing representing the same railroad, also skeleton sketches, track circuit-closers, connecting wires, etc., each part of which is placed immediately below the position it occupies in the perspective view. A train approaching on a down track, on the right-hand end of the drawing, running in the direction of the arrows, its wheels would come in contact with track circuit-closer lever T 1. Each wheel would thus cause the circuit-closer between wire a 1 and wire B 1 to be temporarily closed. This would complete a circuit from battery X by main wire B, branch wire B 1, to and through circuit-closer T 1, wire a 1, to binding screw on signal instrument D 1, to which one end of a magnet wire is attached (this magnet, when vi-
267 talized, causes the danger or red signal to be displayed, when it is held displayed by a retaining lever or catch after the cessation of the momentary vitalization of the magnet), to and through this magnet to binding screw, to which the other end of the magnet wire is attached, to branch wire A 1, main wire A, to the opposite pole of battery X.

Thus has been shown the path of the momentary current. The red disc A 1, of signal D 1, in assuming its position before its window, will temporarily close circuit-closer K, which will temporarily complete the circuit from battery X, by main wire A, branch wire A 1, to and through circuit-closer K on signal D 1, by wire d 1 to a binding screw on signal S 1, to which one end of the magnet wire was attached, (this magnet, when thus vitalized, will cause the blue signal disc of signal S 1 to be raised out of sight from before its window, when it will be retained in position by a retaining lever, after the cessation of the momentary current which caused the said magnet to be vitalized), from the other end of the magnet wire to branch wire B 1, main wire B, to opposite pole of battery, thus completing the temporary circuit. These two signals will remain in position in which, it has just been shown, they were held by their retaining levers, until the train enters the next section mile-block, No. 3, when the signals D 3, S 3, will be operated in a precisely similar manner. The train continuing past this signal block, No. 3, and immediately before reaching the track circuit-closer, T 1^1, will now have two red signals in its rear; one of which, block No. 1, will be a mile or more in the rear, and the other one, block No. 3, in its immediate rear.

The train now being protected by the signals of block No. 3, will open the section protected by the signals of block No. 1, as soon as its wheels come in contact with the lever of track circuit-closer T 1^1. Said circuit-closer being placed a sufficient distance in advance of the signals of block No. 3, to allow the rear of the longest train to be protected by the signal D 3, before the forward end of the train operates the track circuit-closer T 1^1, the wheels of the
268 train will cause this circuit-closer to temporarily complete the circuit from the battery X, by main wire B, branch B 1, to and through circuit-closer T 1^1, wire *c* 1, to binding screw on signal S 1, to which one end of a magnet wire was attached (this magnet, when temporarily vitalized, will remove the retaining lever, which has previously been described as holding the blue signal in its concealed position from before its window, thus allowing the blue signal to be displayed or assume its normal position), to binding screw to which the other end of this magnet wire is attached, to wire *d* 1, to a binding screw on signal D 1 (this magnet, when temporarily vitalized, will remove the retaining lever which has previously been described as holding the red signal displayed before its window, thus allowing the red signal to be concealed or assume its normal position), to a binding screw to which the other end of the magnet wire is attached by branch wire A 1, main wire A, to opposite pole of the battery, thus completing the circuit, and also open the section of track that was protected by signals of block No. 1, for the entrance of a following train.

The remaining signals shown on the drawing, numbered 3, 5, 2, and 4, operate precisely in a similar manner; each similar part being marked with similar letters of reference as used in the description of block signal No. 1, and each letter of reference being followed by the number of block signal to which the part belongs.

Int. 1. Did you find any practical difficulty in operating the system which you have thus described as applied on the Eastern R. R. in the winter of 1873–1874?

Ans. Yes, sir; we first fixed a section of the signals between Lynn and Salem; the instruments had been changed over to adapt them to the one-battery system, being the same instruments that had been used previously in the multiple system of batteries, with the exception of said change. The first difficulty we found was that the magnets being wound with course wire, and thus adapted
269 for the short circuits and comparatively weak batteries with which they had previously been used, required too much battery power to work them on a long circuit; therefore when a battery was applied strong enough to work the most distant signal, which signal would have the longest circuit of any of them, it made the current too intense when the signal nearest the battery, which would be on the shortest circuit, was operated, to work satisfactorily. The spark, on breaking contact with the circuit-closer of this short circuit, following in a burning flame between the points of the circuit-closer—after the said points were removed from each other their proper distance—destroyed the points and burned them up.

This plan of working the signals necessarily made the circuits of the different signals of different lengths.

To more fully show the difference in the length of the different circuits, I refer again to the plan, drawing Exhibit No. 10, where it can be seen that the circuits of the block signal No. 1 would be the longest, as that signal is the farthest from the battery X; but if we operated block signal No. 5, the circuits thus made would be the shortest of any shown on the plan, as that signal is the nearest the battery X.

This difficulty showed that it would be necessary to equalize the resistances of the different circuits belonging to the different signals.

Int. 2. Can you state how long this burning flame spoken of was in any instance?

Ans. With the battery used strong enough to work the most distant signal, which said battery being composed of forty-seven cups of carbon battery, the flame on the shortest circuit would be from a quarter to three-sixteenths of an inch in length on breaking contact between the points of a circuit-closer.

Int. 3. In view of this difficulty, was any change made in the construction of the signal apparatus on the Eastern R. R. at this time?

Ans. Yes, sir. A change was made for the purpose of
270 equalizing the circuits of the different signals, which consisted in a change of connecting the main line wires A and B to the battery X, and also in bringing the ground into use to form part of the circuits.

Int. 4. Look at the paper which I hand you, and state if you know who made it, when it was made, and what it represents.

Ans. It is a sketch which I made.

(Defendants' counsel lay in evidence the sketch referred to in the above answer, which is marked Exhibit 14, E. E. M., ex'r, June 7th, 1877.)

I made this about the 14th of February, 1874, and sent it to Mr. Hall, to show the way to overcome the difficulty, on said 14th day of February, 1874. This sketch fully shows the change made in connecting the main wires A and B to the battery, and the use of the ground, in contradistinction to the mode of connection shown in Exhibit No. 10.

Witness is shown Exhibit No. 8.

Int. 5. Please compare Exhibit No. 8 and Exhibit No. 14, and state how far they correspond.

Ans. Exhibit No. 8 shows the same plan as Exhibit No. 14, as far as the main wires, A and B, and their connections to the battery and to the earth are concerned, but, in addition, it shows the detailed connection of a number of signals, circuit-closers, etc., to the said wires.

Int. 6. Look at the description in Exhibit No. 8, at the foot of the drawing, and state whether or no it is correct.

Ans. Yes, sir; as far as it goes. It is not a detailed description of the whole thing.

Int. 7. When did you actually begin the change of the Eastern R. R. signal apparatus to the ground-circuit plan?

Ans. About noon, the 14th day of February, 1874, and the change was made through the section between Salem and Lynn, which is about five miles long. As soon as it was seen how this change could be made so as to equalize the resistances of the circuits, I sent a man to Lynn to make the necessary changes in the ends of the line wires at that point, and, with the assistance of a second man, made the necessary changes at the Salem end of the main wire.

271 As soon as these changes were completed, I saw that the object intended was accomplished.

Int. 8. How long were you afterwards occupied in setting up the apparatus on the Eastern R. R.?

Ans. Until some time in the following July.

Int. 9. What use did you make of the ground circuit plan along the balance of the road beyond Lynn?

Ans. We made the same use of it throughout the road.

Int. 10. Did it or did it not work successfully?

Ans. It did.

Int. 11. Has it been since, to your knowledge, adopted in the construction of the Hall signals on other roads; and, if so, name them?

Ans. It is the only plan that has been used since. It has been used on the Boston, Lowell & Nashua R. R., the Boston & Albany R. R., and the Old Colony R. R.

(Paper laid in and marked Exhibit No. 15, E. E. M., Ex'r, June 7th, 1877.)

Int. 12. Look at Exhibit No. 15 and state if you ever saw it before; and, if so, when you first saw it?

Ans. I saw it first some time in the year 1872, soon after the completion of the work which it illustrates.

Int. 13. State what it illustrates.

Ans. It illustrates the application of the Hall signals to the Harlem R. R.

Int. 14. Were the words written upon it in red and black ink, descriptive of its character—which now appear upon it—on it, when you first saw it?

Ans. They were on it, exactly as they are now, as I remember it.

Int. 15. Look at Mr. Pope's patent, No. 140,536, and state whether you are or are not familiar with that patent and the accompanying drawings?

Ans. I can see what it is.

Int. 16. Have you ever examined it before?

Ans. To some extent.

Int. 17. To what extent?

Ans. To the extent of getting an idea what it says.

272 Int. 18. How many times have you examined it before to-day?

Ans. I do not know as I ever kept any record of the times. I have probably looked at it three or four times.

Int. 19. State whether, in your opinion, this patent, with its speci-

fications, claims and drawings, gives such a description of the invention which it purports to set forth, that a person skilled in the art of applying electro-magnetism to railroad signaling would be able, from this patent, specification and drawing alone, to construct an apparatus which would accomplish the object which the patent purports to be designed to attain, in the manner indicated therein?

Ans. As I understand the question, unless he is acquainted with, or supplied with the signal where it says they "may be of any suitable construction," and "provided with some suitable means of retaining them in position or action after the circuit through the magnet M, M^1 or M^2 had been interrupted," I do not think it does.

Int. 20. Does the patent sufficiently specify a mode of effecting an equality of resistances in the different circuits?

Ans. No, sir.

Int. 21. Could the object of that patent be attained without such an equalization of resistances?

Ans. It could not practically, in case there was a great difference in the length of the circuits.

Witness is shown Exhibit No. 2.

Int. 22. Have you examined that plan and descriptive remarks; and, if so, are they correct?

Ans. Yes, sir; they are.

Int. 23. Did you hear the testimony of Alvah W. Hall in this case, in which he explained that diagram by letters and figures, and the application of the Hall signals at the Grand Central Depot, which it represents?

Ans. Yes, sir.

Int. 24. Was or was not his explanation of the principle and mode of operation of that apparatus correct?

273 Ans. Perfectly correct, to the best of my knowledge.

Int. 25. Comparing this apparatus with that indicated in Mr. Pope's patent, No. 140,536, state whether there is any substantial similarity in the two processes indicated respectively on Exhibit No. 2 and said patent.

Ans. I should say that forming the different circuits between the extended poles of the battery was substantially the same principle, figure 2 of Exhibit 2 graphically showing the formation of the circuits between the extended poles of the battery, as used in the switch signals illustrated by Exhibit No. 2, and figure 3 on the same exhibit showing the making of the circuits between the extended poles of the battery, as shown in Pope's said patent.

Cross-examined by Mr. HALL:

Cross-int. 26. Prior to your acquaintance with Mr. Hall, which you have stated commenced in May, 1870, what was your education?

Ans. My education was a common school education, as far as outside education is concerned. I did not go to school after I was sixteen, except a course in a commercial college when I was about eighteen.

Cross-int. 27. Did your knowledge obtained at school extend to scientific subjects, including electricity and magnetism?

Ans. No; not further than the common school philosophies of thirty years ago would extend.

Cross-int. 28. Had you, at the time of making the acquaintance of Mr. Hall, any previous knowledge or experience whatever in regard to the application of electricity and magnetism to mechanism; and, if so, what?

Ans. Yes, sir; I had some general knowledge of it from reading scientific papers and books.

Cross-int. 29. Had you obtained sufficient knowledge of said subject prior to 1870 to enable you to take the sole care of signal batteries and electrical apparatus as then applied to the railroad at Stamford?

274 Ans. Probably not, without further study, which could be soon acquired by myself, in my own judgment.

Cross-int. 30. Did you obtain such knowledge from reading and study, or did Mr. Thomas S. Hall impart it to you?

Ans. In both ways, and by any other means I could find of learning.

Cross-int. 31. Did you understand the application and practical operation of T. S. Hall's signal apparatus at Stamford before an explanation to you by Mr. Hall, and specification?

Ans. Probably not, as near as I can remember.

Cross-int. 32. Describe, in detail, the signal apparatus and its application to the railroad, as you first saw it at Stamford, from memory.

Ans. As I remember the application of Hall's signals at a highway crossing near Stamford, where I first saw them, in 1870, there was a house of suitable size to contain a number of battery cups. On the top of this house was constructed a case for containing and exhibiting a visual signal. This house was situated at the side of a highway crossing near the tracks of the N. Y. & N. H. R. R. About half a mile from this house, eastwardly, was situated an instrument for closing the circuit on a battery for the purpose of exhibiting a signal at the highway crossing, to give notice that the train was approaching the crossing from the east.

This circuit-closer was put in operation by the wheels of an approaching train coming in contact with a part of its mechanism, when a signal was exhibited at the crossing by these means. It remained in the position of showing the approach of a train until the train had reached or just passed the crossing, when the train closed another circuit, by means of a similar mechanism to the circuit-closer previously described, which caused the signal to be withdrawn from sight.

On the other track were placed similar circuit-closing in-
275 struments, placed in the proper positions to perform the same operation on the signal when a train approached from the west on the said track.

Wires led from the battery in the said house to the different circuit-closers on the tracks.

The signal was held in position of danger by a constant current of electricity from a battery flowing through its magnet wire. The means of keeping this constant current flowing through the magnet wire of the signal was by aid of another instrument called a double-circuit instrument; this instrument being so constructed that a train approaching the crossing, and operating the distant circuit-closers which have been before mentioned, would cause a magnet to be vitalized on this double-circuit instrument, thus making the magnet attract an armature, said armature being fastened to a short arm of a lever, thus causing the longer arm of the lever to move a certain distance. This movement allowed one end of a second lever to fall behind the long arm of the first-mentioned lever, when the first-mentioned lever was thus moved; and it would thus hold the first-mentioned lever in its moved position after the vitalization of the magnet had ceased.

The end of the long arm of this first lever was attached to the long arm of a third lever by a connecting link, and to the short arm of the third lever was attached circuit-closers, so that when the long arm of the first-named lever had been moved by the attraction of its armature, said circuit-closers would be closed. To the points of these circuit-closers were attached wires that included a second battery, and the magnet of the signal instrument, in their circuit. Thus, when the circuit-closers on the double-circuit instrument were closed, the current from the second battery would flow through the magnet of the signal, causing the magnet to attract its armature; said armature being attached to one end of a lever, said lever being a part of the system of compound leverage. To the other end of said leverage an arm was attached, to which arm a signal disc was attached in such a manner that the small
276 movement of the armature, when attracted, would be increased at the other end of the leverage, sufficiently to cause the arm, to which one end of the signal disc was attached, to make about a quarter of a revolution on its axis in a vertical plane. This part of a revolution, when completed, brought the red disc before its exhibition window; the signal would now remain in this position till the train wheels operated the circuit closer mentioned as being near the crossing, which would cause the current to flow from the first battery through a second magnet on the double-circuit instrument, causing the magnet to attract an armature; said armature being attached to the second lever in such a manner that its movement, when attracted, would pull the second lever away from its position of holding the first lever in its moved position, thus allowing the first lever to assume its normal position by means of a spring, the said spring having a tendency to move the first lever in an opposite direction to its movement when its armature was attracted. This releasing of the first lever would also release or open the circuit-closers attached to the third lever, and thus the continuity of the circuit which had been established between the signal magnet and the second battery would be discontinued, the magnet of the signal thus losing its magnetism, and thus ceasing to attract its armature, which would allow the signal disc to fall

by the attraction of gravitation to its normal or concealed position, or *the non-approach-of-a-train position;* the second lever mentioned on the double-circuit instrument being made to fall behind the first lever by means of a spring, said spring moving the lever in an opposite direction to its movement when its armature is attracted.

On the signal house was placed a bell, the bell being rung by electro-magnetism to give audible notice of the approach of a train. This bell was so constructed that when its magnet was vitalized it attracted an armature; said armature being attached to a rod, to one end of which a hammer was fastened to strike the bell. When the magnet was not vitalized, the hammer was held away
277 from the bell, and the armature from its magnet, by means of a spring, and when so held away, a point on the rod rested against another spring, to which spring one of the wires intended to form a part of the circuit for the purpose of ringing the bell was attached. To the rod to which the hammer and armature was attached was fastened one end of the magnet wire; the other end of the magnet wire leading to one pole of the battery by which the double-circuit instrument was worked.

Now, if a wire led from a spring, against which the hammer-rod is said to rest, to the other pole of the battery, a circuit would be formed, the point of said spring resting against the hammer-rod forming a part of the circuit, and causing the magnet to be vitalized and to attract its armature and cause the hammer to strike the bell. This attraction of the armature would draw the hammer-rod away from the point of the spring against which it rested, and thus break the circuit, which would cause the magnet to lose its magnetism and allow the hammer-rod to again rest against the spring, thus again completing the circuit and striking the bell, which operation would continue as long as the wires were thus attached to the battery.

The manner of attaching this arrangement to the signal was in the following manner: Near the end of the long arm of the lever, to the short end of which the armature of the signal instrument previously described was attached, was connected the long arm of a second lever, by means of a connecting link; to the short arm of said second lever circuit-closers were attached in such a manner that when the signal disc was concealed these circuit-closers would be open, and when the signal disc was displayed they would be closed.

To one point of this circuit-closer was attached a wire leading to one pole of the double-circuit battery. From the point of the circuit-closer a wire led to the spring against which the bell-hammer rod of the bell rested. Thus a circuit would be formed from one pole of the battery to and through the circuit-closers, just as described, to the spring against which the bell-hammer rod
278 rested, through the bell-hammer rod to and through the magnet wire, to and through a wire leading to the opposite pole of the battery, which, from the previous description of the construction of the bell, will show how the bell was made to ring continuously by the closing of the circuits, when the signal was displayed to denote the approach of the trains, and that the bell would cease

ringing when the circuit-closer on a signal was opened by the concealing of the signal disc.

Cross-int. 33. What changes were made by you in the arrangement described in the last answer, and seen at Stamford during the summer and fall of 1870? Describe these changes in full.

Ans. One of the changes consisted in applying a new track instrument for closing the circuits. The object of this new circuit-closer was to simplify the mechanism of the apparatus and make it more compact and durable, its function being the same as the previous one used. Some other work that I have done was to rearrange the wires and relay the wires that run under ground, in place of old lead-covered, gutta-percha insulated wires that had been there. A further improvement made in the arrangement was to place a second double-circuit instrument in the application. In the application, as I have previously described it, as made, in case a train was approaching on each track, the double-circuit instrument being used for each track, would cause the first train that reached the crossing—providing that one of the trains was nearer the crossing than the other, each train being within its signaling distance—to stop the display of the signal before the other train passed the crossing. By the adding of this second double-circuit instrument the signal was made to remain displayed until the last of these two trains had passed the crossing. This second double-circuit instrument used the same battery power, or power from the same battery, one double-circuit instrument being connected with the raising and concealing track circuit-closers of one track, and the other
279 double-circuit instrument with the raising and concealing of the circuit-closers of the other track. The circuit-closers on the short end of the third lever of each double-circuit instrument closed the same circuit that included the signal magnet and its battery in such a manner that if the circuit-closers on either one of the double-circuit instruments was closed, the signal would be displayed; and if the circuit-closers on both the double-circuit instruments were closed at the same time, the signal would be displayed, and would remain so displayed; and if either one were opened, until both were opened—thus showing that each train would close and open its circuit-closer on its double-circuit instrument, which instrument was connected with the train's own track. Thus means were provided for keeping the signal displayed at the crossing until the last of two approaching trains—one train being on each track—had passed the crossing.

Cross-int. 34. Did you or Mr. T. S. Hall invent this new circuit-closer?

Ans. I made the drawings and plan of it. I did not consider it an invention, but merely a change in the arrangement of the parts. I think I suggested it to him.

Cross-int. 35. Did you suggest the improvement upon the circuit-closer?

Ans. Yes, sir; if you mean the track circuit-closer.

Cross-int. 36. Who was in charge of the work of putting up the

crossing signals on the Hartford & New Haven R. R. and the Flushing R. R. in 1870 and 1871?

Ans. I should say that Mr. Thomas S. Hall was.

Cross-int. 37. Were there any other than crossing signals and signals similar to those you have described put up by Mr. Thomas S. Hall before these put up on the Harlem R. R. in New York city?

Ans. Yes, sir.

Cross-int. 38. What were those, and where?

Ans. On the New York & New Haven R. R. there were some draw-bridge signals; one at Bridgeport, one at South Norwalk; also a switch signal at Stamford, and at the junction of the Hart-
280 ford & New Haven R. R. with the Air Line R., R. near Cedar Hill, New Haven, was a junction signal to give notice to an Air Line train approaching the junction from the east, that a train was approaching the same point on the New Haven & Hartford R. R.; signals were placed at Tarrytown, a certain distance on either side of the station, and gave audible notice at the station that a train was approaching, and gave visual notice to following trains that the track between the signals and the depot was occupied by a previous train.

Cross-int. 39. State what you had to do with putting these signals up.

Ans. I had nothing to do with the Bridgeport and South Norwalk draw-bridge signals, nor with the putting up of the original switch signal at Stamford. I done the work with the help of other men, of putting the signals at Tarrytown and Cedar Hill.

Cross-int. 40. Was the application of the signals shown in Exhibits 4 and 9 made under your direction?

Ans. The manual labor was under my immediate supervision, being, of course, subject to the wishes of Mr. Hall.

Cross-int. 41. Did he direct any application of the signals shown in Exhibits 4 and 9?

Ans. He gave general directions to me of what was wanted.

Cross-int. 42. Who made the plans according to which the details were carried out?

Ans. I made my own sketches and plans, and sometimes worked without any.

Cross-int. 43. Were any other plans drawn other than yours from which work was constructed?

Ans. Not that I remember of. I would like to say that the large signal-house that stood north of the Grand Central Depot, and some bell cases in the depot, were designed by other persons than me.

Cross-int. 44. When was the work actually commenced of putting up the signals at the Grand Central Depot and upon the Harlem R. R., as shown in Exhibits 4 and 9?

281 Ans. To the best of my recollection it was the first of the summer of 1871.

Cross-int. 45. When was the apparatus at the track crossing shown in Exhibit 9 completed and first put in use for controlling the movement of trains?

Ans. As well as I can recollect, it was near the middle of the winter of 1871–'2.

Cross-int. 46. You stated in your direct testimony that you received a telegram from Mr. Hall to come home about the 20th of January, 1873, and that upon reaching home you had a conversation with him in the shop at New Haven. Did that conversation occur immediately after your arrival?

Ans. Yes, sir.

Cross-int. 47. Was this conversation before you saw the model set up in the shop at Meriden?

Ans. As near as I can tell, it was immediately before I saw the model.

Cross-int. 48. Are you able to state positively whether it was before or after you saw the model?

Ans. I am not able to state positively.

Cross-int. 49. Detail minutely all the conversation between you and Mr. Hall at the first interview after your arrival from Boston in answer to the telegram referred to.

Ans. I could only give such portions of our conversation as related to the object for which he wished me to come home. The object was to get a number of signals to work by means of one battery, which required a change in the signaling instruments. He gave me to understand that he had a plan whereby he could work a number of signals, and said in substance that he could work signals all the way between Boston and New York by means of one battery, which plan consisted in extending the poles of the battery the distance the signals would be required to work, and attaching the signals to the said extended poles in a proper manner. He one day asked me how long the long arm of the first lever on a double-circuit instrument would have to be extended to display and conceal a signal
282 disc placed on the extreme end of such extension, when the short arm of the first lever was moved by the attraction of its armature, and then released from said attraction. The answer I gave him was, that it would have to be sixteen or seventeen feet. The object was to use the double-circuit instrument as a direct means of showing a signal, and also to avoid the necessity of keeping a circuit constantly closed as long as a signal might be displayed; thereby better adapting signals to a one-battery system. I told him, in substance, that would not be the way to construct it, and that the same effect could be produced by a system of compound levers, which would have the same effect, when properly compounded, as a long lever would have, thus condensing the room that the signal would occupy; and I further told him, that all that it would be necessary to do, would be to place a retaining lever, similar to lever No. 2, previously described, on the double-circuit instruments, in connection with its armature and attracting magnet, in a position under the long arm of the lever of the signal instrument, the short arm of the said lever carrying the armature, the said armature, when attracted, being the means of displaying the signal. The said armature, when attracted, would take a down-

ward direction, which would cause the long end of said signal lever to take an upward direction, and thus allow a projection.

Hearing adjourned to June 8th, 1877, 10 a. m.

NEW YORK, *June 8th.*

Cross-examination of Mr. SNOW continued. Counsel in attendance, as before. Witness continued his reply to cross-int. 49, as follows:

And thus allow a projection fastened to the under side of said signal lever to be raised with the lever a sufficient height to allow the newly added retaining lever to catch under the said projection, by the force of a spring.

283 Cross-int. 50. Are you confining yourself to the first conversation after you returned from Boston in obedience to Mr. T. S. Hall's telegram?

Ans. The foregoing is not all the direct conversation; some of it is explanatory.

Cross-int. 51. When Mr. T. S. Hall told you he could work all the signals between New York and Boston from one battery, what reply did you make?

Ans. I do not remember.

Cross-int. 52. What was your opinion at that time?

Ans. As near as I can recollect, it was that he could not do it.

Cross-int. 53. When did you commence making the first signal in which the locking lever or detent acted directly upon the signal without the intervention of the double-circuit instrument, and when was it completed?

Ans. We made it in the shop in New Haven between the time of my arrival there, about the 20th of January, 1873, and completed it before the shop was removed to Meriden.

Cross-int. 54. Was it practicable to display a signal like that shown in B, in Exhibit 9, for example, by connecting it directly to a track instrument, similar to those shown in Exhibit 4 and used on the Harlem R. R., without the intervention of a double-circuit instrument?

Ans. Not as signal B was constructed.

Cross-int. 55. Were the signals in use on the Harlem R. R. and on the Eastern R. R. prior to the time of your conversation with Mr. Hall, at New Haven, in January, 1873, constructed substantially like the one designated B, in Exhibit 9, and referred to in the last answer?

Ans. Yes, sir; with the exception of the frame of the signal being constructed, in some, to show the signal-disc when in its normal position, and some so that the signal would be concealed in its normal condition, the difference being made for the purpose of fastening the signals in their cases.

284 Cross-int. 56. Did these signals require a continuous current, in order to retain them in a position of display or concealment, other than their normal position?

Ans. If you allude to the ones named in your last question, they did.

Cross-int. 57. What change in the apparatus, other than that you have mentioned for operating the signals, as that apparatus existed at the time of your conversation with Mr. Hall, in January, 1873, if any, was necessary in order to operate a number of signals from one battery?

Witness says: I would like to ask if, by apparatus, you mean the instrument simply, or only the whole thing, including the wires, etc.?

Counsel replies: Simply the instrument.

Ans. Changes had to be made in the circuit-closers on one signal that were intended to operate the second signal, so that the circuit would be only temporarily closed by them. Circuit-closers attached to railroad switches had to be changed for the same reason.

Cross-int. 58. When did the idea first occur to you that it was necessary to make this change in the track circuit-closer, which was in use prior to January, 1873?

Ans. Soon after I took the job of making Mr. Hall's instruments at my shop in New Haven, 1870.

Cross-int. 59. When did you commence the construction of the first track circuit-closer which was adapted to the purpose of working several signals from one battery?

Ans. I did not construct any track circuit-closers for the purpose of adapting it to the working of a number of signals from one battery.

Cross-int. 60. Who did construct them?

Ans. I do not know that there were any constructed for that special purpose.

285 Cross-int. 61. In your direct evidence, page 43, you say: "Down to this time, and after April, 1873, at the shop in Meriden, we were employed in making a change in the signal instruments; the changes made were these: We made a new track circuit-closer and the tools for making the same; also a change in the signal," etc. Also, on page 45, you testified that "the object of said work in part was for the purpose of making such changes as would enable you to work a number of signals from one battery." Now, if you were not employed in the construction of the new track circuit-closer, adapted to the working of a number of signals from one battery, explain what you meant by the portions of testimony quoted.

Ans. The idea of making some improvement in the track circuit-closers had occurred to me before my going to New Haven in answer to Mr. Hall's telegram of January, 1873, and the making of the improvement was more for the overcoming of the defects in the old machine than for any other purpose; and when we got it completed we found that it would answer for the one-battery system much better than the old machine.

Cross-int. 62. Have not you said that the circuit-closer in use prior to January, 1873, was not adapted to the purpose of working a number of signals from one battery?

Ans. I have said the track circuit-closer in use prior to 1873 was

not adapted to work a signal like signal B, in Exhibit No. 9, without the intervention of a double-circuit instrument; that is all that I think of.

Cross-int. 63. Would such circuit-closers, in your opinion, successfully operate directly, from one battery, a number of signals, similar to those shown in Exhibit 10?

Ans. I think they might operate them about as well as they did the old instruments, although I never tried it practically upon them personally.

Cross-int. 64. Would it be safe to use such circuit-closers for operating a series of signals from one battery, as shown in Exhibit 10, for controlling the movements of railroad trains?

286 Ans. I don't think the safety of the signal system consists in the working of the circuit-closer; the signals being so arranged and the rules of running trains by them being intended to show danger or safety, whether the signal operates properly or not.

Cross-int. 65. Does not the practical utility and value of the signal system depend upon its acting correctly and with certainty, so as not to delay or embarrass the movement of the trains?

Ans. Yes, sir; it does. But the delaying of trains should not be counted against the safety of them.

Cross-int. 66. When was the construction of the first track circuit-closer which was practically adapted to the purpose of working a number of signals from one battery, commenced by you, or others, in the employ of the company represented by Thomas S. Hall?

Ans. The first track machine of the kind which was practically used in working a number of signals by one battery, was commenced by myself in the shop in New Haven, prior to moving the shop to Meriden, in 1873.

Cross-int. 67. When did you first make a practical test of its working?

Ans. Soon after moving to Meriden; some time the latter part of April, 1873, I placed one on the track of the Hartford & N. H. R. R. and connected wires to it leading to the shop, and the wires were connected to a battery and signal, so that passing trains would operate the signal. This machine was afterwards used for operating crossing signals on the same railroad.

Cross-int. 68. Referring to your evidence on page 44, wherein you state that in January, 1873, you saw what the model and plan Exhibits 5 and 6 represent; did you at that time observe any visual or audible signal operated in connection with the apparatus?

Ans. I think there was an audible signal attached.

Cross-int. 69. Are you able to state positively that there was an audible signal attached?

Ans. No, sir; I am not.

287 Cross-int. 70. Did you at that time see any circuit-closer adapted or arranged to be operated by moving trains in connection with the apparatus represented by Exhibit No. 5?

Ans. I remember the application, the same as Exhibit No. 5 illustrates.

Cross-int. 71. From the time of making this experiment just

referred to, was you engaged till November, 1873, exclusively, in making circuit-closers and alterations in the signals to be used on the Eastern R. R.?

Ans. No, sir; I was engaged part of the time in making the tools for making the improvements, drawings, and other necessary work; all that I did during said period was connected with these alterations and improvements.

Cross-int. 72. State as accurately as possible the length and size of the cores of the magnets used for operating the signals, with which you made the first experimental trial of the one-battery plan, between Salem and Lynn, at the time you have stated the circuit-closers were burned.

Ans. As near as I can state, the magnet cores used for raising the signal were about three inches and seven-eighths in length, and about five-eighths of an inch in diameters, the heads on the end of the cores, for making a spool out of the core, being about an inch and five-eighths in diameter. The magnets for reversing the signals or moving the detaining lever, I think were about two inches and an eighth long, and about a half an inch in diameter, and the heads or spool ends about an inch and a quarter in diameter.

Cross-int. 73. Of what sized wire were the coils of these magnets composed?

Ans. I cannot give the size of the wire-gauge by wire measure; the spools were wound full, and some of the large spools I figured as having 970 odd convolutions, and others about 400—I mean for both spools composing the magnet.

Cross-int. 74. Was any alteration made in the size of the
288 wire of the signal magnets before the first arrangement on the Eastern R. R., corresponding to Exhibits 5 and 6, was abandoned by you; and if so, what?

Ans. About this time, previous to the abandonment of the first idea, I found that the magnets, that I have just described as being wound with the greater number of convolutions of wire, worked on a long circuit, with less amount of battery power than those wound with the less number of convolutions of wire; and by experimenting further I had magnets wound with still finer wire, till I got the size which I thought about right, which I finally adopted, and which was No. 26 wire, which was wound on the same sized spool, the spools being filled.

These experiments with the wire were carried on immediately before and after the burning of the circuit-closer.

Cross-int. 75. Have you stated all the steps taken by you in experimenting, from the time of the first unsuccessful experiment until the time of the first successful one, February 14, 1874; if not, state them?

Ans. Not in detail. I have generally, as far as anything I think of, at present.

Cross-int. 76. Did you learn that any trouble, of the kind stated by you, would be experienced, owing to the unequal resistances, until you attempted to put the system in practice?

Ans. Not that I remember of.

Cross-int. 77. Had you made an actual experiment with the arrangement shown in your sketch, Exhibit 14, before you sent it to Mr. Hall?

Ans. Yes, sir.

Cross-int. 78. Was the experiment entirely successful?

Ans. For equalizing the currents, it was, in my estimation.

Cross-int. 79. Describe the experiment you made, in general terms?

Ans. The experiment consisted in disconnecting one of the wires from the pole of the battery, which it had been an elongation of, and leaving the disconnected end free or open, and connect-
289 ing the extreme end with the earth. The disconnected pole of the battery was then connected direct to the earth. The opposite pole of the battery elongating wire was left free and open, the connection of the branch wires, from the signal instrument to the main wire, remaining the same.

Cross-int. 80. Did you actually operate a number of signals at different points along the railroad by one battery before you sent sketch Exhibit 14 to Mr. Hall?

Ans. Yes, sir.

Cross-int. 81. When you sent sketch Exhibit No. 14 to Mr. Hall did you write him a letter?

Ans. Yes, sir; the sketch was inclosed in a letter to him.

Cross-int. 82. Did you keep a copy of that letter?

Ans. I kept a copy of some letters, and I do not know but I have a copy of that one.

Cross-int. 83. If you have preserved a copy of this letter will you present the same and attach it to your evidence in this case?

Ans. I have a copy of the letter accompanying the same, which I here present.

Letter presented and marked Exhibit H, E. E. M., Ex'r, June 8, 1877.

Cross-int. 84. Have you the letter that was written to you by Mr. Hall in reply; and, if so, please present it?

Ans. I do not know as I have it. I will look and see. I find a letter of Mr. Hall's of Feb. 16th, 1874, but on examination I do not think it is Mr. Hall's reply to the letter of mine referred to.

Complainant's counsel desire to have the letter laid in, which is done, and the letter is put in evidence and marked Exhibit I, E. E. M., Ex'r, June 8th, 1877.

Cross-int. 85. Will you present and attach to this evidence all the correspondence between you and Mr. Hall relating to sketch Exhibit No. 14?

290 Ans. I have no objection to doing so, what I can find of it. I have only copies of such letters as I sent to Mr. Hall.

Cross-int. 86. State briefly, and in substance, the reply of Mr. Hall to your letter of Feb. 14th, 1874.

Ans. I do not recollect.

Cross-int. 87. Not any part of it?

Ans. No, I do not. It may be possible that there was never no direct answer to it.

Cross-int. 88. Did you, in the course of your experiments at this time, try any other methods of equalizing the several circuits, or of obviating the burning of the circuit-closers?

Ans. I thought of some other methods, but did not try them.

Bross-int. 89. How many convolutions of wire were there, or what was the size of the wire used upon the signal magnets, in the final and successful experiment?

Ans. I think they were the same magnets that we had been using previous to the equalization of the circuits.

Cross-int. 90. Did you adopt No. 26 wire before or after the successful experiment of Feb. 14, 1874?

Ans. After.

Cross-int. 91. State the actual saving in battery, wire,
291 signal houses, and expense of attendants, on the Eastern R. R., by use of the one battery system rather than the old system.

Ans. I could not state the whole of it without data to refer to. Generally, I will say that as far as the saving of battery is concerned, that, in the former multiple system of batteries, the amount of battery used was about 1,700 cups of the Daniel battery, and in the new system about 300 cups of gravity battery, Callaud. The saving of wire would not amount to much, and the saving of attendants would be a reduction of about two-thirds; the houses were the same.

Cross-int. 92. Did not the Eastern R. R. Co. discontinue the running of trains by these signals, as arranged with separate batteries, during the winter of 1872–'3, in consequence of the difficulty of maintaining so many separate batteries, situated at exposed points, in a state of efficiency?

Ans. About the latter part of November, 1873, they discontinued the use of the signals, as I understood it, because of their not working satisfactorily; one cause of their not so working, probably, being the difficulty in taking care of the batteries, and of not taking care of them.

Cross-int. 93. At the date of Pope's patent, July 1, 1873, were not electric signals known or in use, which were so constructed as to be displayed by the action of the electric current upon one magnet, and subsequently reversed or concealed by the action of a current upon another and separate magnet?

292 Ans. I do not recollect of having seen any electric signals in operation previous to that time, excepting Hall's.

Cross-int. 94. Were the signals shown in Exhibit No. 2 situated along the road at intervals, or were they all grouped in one signal-house?

Ans. The visible signals were placed in one house situated north of the Grand Central Depot, between 46th and 47th streets, and the audible signal was about a block further north.

Cross-int. 95. Were the circuit-closers for raising, or those for reversing the signals, situated at intervals along the line of the rail-

road, or were they all at one point, a few hundred feet from the signals?

Ans. The circuit-closers for raising the signals were grouped together in the train-dispatcher's office. The circuit-closers for reversing the signals were grouped together in the switchman's shanty, on which the audible signal was placed.

Cross-int. 96. Were they operated by, or did they depend upon, the movement of the trains?

Ans. No, sir.

Cross-int. 97. Did it not require two separate batteries to operate the signals by the system shown in Exhibit No. 2?

Ans. The exhibit shows that it did.

293 Cross-int. 98. In your opinion, could a person skilled in the art, by means of the apparatus and method shown in Exhibit No. 2, without further additions or inventions, construct a practically useful series of automatic block signals, which could be placed at intervals along the line of a railway, and operated by a single battery?

Ans. No, sir.

Re-examined by Mr. BALDWIN:

Re-E. 99. Do you recollect whether the apparatus represented by Exhibit No. 6 was connected with the railroad track, and was visual or audible signals at any time during 1873?

Ans. Not as this exhibit shows.

Re-E. 100. Was any similar application, on the one-battery plan, made to the track at Meriden in that year?

Ans. No, sir.

Re-E. 101. Do you recollect when the first improved track circuit-closer was actually applied to a railroad track, in connection with a number of double-circuit instruments, designed to operate a number of signals from one battery?

Ans. The improved track circuit-closer was applied to railroad track in the latter half of April, 1873; there being only the one, it could not be used to raise and reverse a number of signals automatically, but it was connected to a signal some time, so that a passing train would raise a signal, and at other times reverse it.

294 Re-E. 102. State where and what were these signals with which it was connected.

Ans. The signals were the kind that had the retaining lever attached to them, such as we have recently been making, and were in the shop of the signal company at West Meriden. These signals were visible signals. A striking bell or audible signal was connected to a circuit-closer on a signal to strike when a signal was displaying, and momentarily closing the circuit.

Re-E. 103. Where were the instruments placed by which these signals were operated? I do not refer to the track circuit-closers.

Ans. They were placed in the shop.

Re-E. 104. Did you take out a patent in 1873 for the use of what I may call an air-cushion in constructing track machines?

Ans. Yes, sir.

Re-E. 105. Was the introduction of this air-cushion one of the changes in the track machines in which you were engaged during part of 1873 after your return from Boston?

Ans. The air-cushion constituted a part of the track machine which we made that summer and which was patented.

Cross-int. 106. Did the circuit-closer which you tried on
295 the track at Meriden, in the latter part of April, 1873, contain the device of the air-cushion to which you have referred?

Ans. Yes, sir, it did.

GEORGE H. SNOW.

Subscribed and sworn to before me this 8th day of June, A. D. 1877.

E. E. MARVIN,
U. S. Com'r & Ex'r.

Hearing adjourned to June 19th, at the same place, at 10 a. m.

296 THE ELECTRIC RAILROAD SIGNAL CO.
vs.
THE HALL RAILWAY SIGNAL CO.

TUESDAY, *June 19th*, 1877.

Defendant's evidence taken at New Haven instead of New York, by consent.

Present: Mr. Perkins for the complainants, and Mr. Baldwin for the defendants.

CHARLES H. MANSUR, a witness offered by the defendants, sworn

My name is Charles H. Mansur; my age is 40; I am employed by the Hall Railway Signal Co.; and my residence is West Meriden, Conn. I came directly in the employ of T. S. Hall, Jan. 9th, 1871, and have remained in his employ, and that of the companies he represents, ever since. I have had charge of the shop, in making railway signals, and doing work connected with it. Prior to that, I had been engaged at my trade, which is that of a machinist, with Snow & Coe. From May, 1870, till Jan. 9th, 1871, I had been making tools and patterns for electric instruments for the company represented by Mr. Hall. I think I first heard Mr. T. S. Hall speak of being able to actuate a series of electric signals by means of a single battery some time in Dec., 1872. He said in substance that he had a plan whereby he could operate a series of signals by one battery.

This was in the shop at New Haven; the shop was located corner of Whitney Ave. and Howard St. He did not at that time give me any explanation of the plan, but a few days afterwards he came to the shop and made an experiment with some double-circuit instruments to show how he could operate a series of signals by one battery.

297 We had two or more double circuit instruments similar to Exhibit No. 3, so connected as to raise or reverse a signal; that was the idea. I mean that the instruments were connected

with a battery, and with each other. Electric force was actually applied; wires were connected from the batteries with the raise magnet; also with the reverse magnet, and with the relay wires for operating another double-circuit or signal instrument. It worked. Mr. Hall said, after he had experimented with it, that he was perfectly satisfied that he could work a series of signals; and in a very short time he commenced to make alterations in signal instruments, for the purpose of operating a series of signals for one battery. Under Mr. Hall's directions I commenced to make and put on to the signal what I called a double-circuit instrument or retaining lever.

(Defendants' counsel place in evidence a signal instrument and disc, and which is marked Defendants' Exhibit No. 16, E. E. M., June 19th, 1877.)

The frame of this exhibit was made in the fall of 1872, and it is one of those which I altered over, in the early part of January, 1873. The changes that were made were putting on the black walnut block, and a suitable rest to support the same, the rest being of cast iron, put on the lower part of the black walnut block. On this black walnut block was placed a magnet and a cast-iron stand for holding a lever; and attached to the lever was an armature. This stand was cast-iron, with two brass screws, made for holding the journals of the shaft of said lever. Attached to this lever was a spring, for the purpose of bringing the lever under the catch on another lever, which held the armature of the large magnet on the signal. There was also two binding posts for holding the ends of the magnetic wire, which were fixed on the bottom of the black-walnut block. There was, on the top of the block, a cast-iron stand, with a regulating screw in
298 it, to regulate the distance which the brass lever should catch under the projection of the lever, which has the armature for the large magnet. We also made a change in the rod which connects the long lever to which the large armature of the signal is attached to the short arm, to which is attached the chain which connects with the pulley or wheel. These were all the changes made, I think, at this time.

(Defendants' counsel place in evidence another signal instrument, which is marked Exhibit No. 17, E. E. M., Ex'r, June 19, 1877.)

The frame of this was made about the same time as the other; I presume at the same time. This is the danger signal; the other was the safety signal. It has the same attachments as the safety signal which I have described, and they were put on in the early part of January, 1873.

There is a difference between the attachments of the danger and safety signal. Exhibit No. 16 has an attachment consisting of a ring, with suitable attachments for connecting it with levers above and below.

The lower lever was connected with circuit-closers, and was supported by a cast-iron stand, which has screws, which form the boxes for the journals of the shaft of said lever. Attached to this lower

lever was a suitable connection for connecting an arm which has a relay attached to it.

There was also a relay attached to one end of the lever, a relay spring or circuit-closer. This lower black walnut block, and everything upon it, was a part of the original signal instrument. The only change that I made in respect to that was by substituting this brass hoop, which connects the two levers, in place of a straight rod which had previously connected them.

The reason for making the change was because that, after the upper black-walnut block and attachments was put on, it filled the place before occupied by the straight rod.

299 The difference between Exhibits Nos. 16 and 17 in this respect is this: To go back to Exhibit No. 17, it does not have the lower block's attachments on it. We took off the circuit-closers on the lower black-walnut block, and placed them above, where they are not shown in this exhibit. They were put on the iron back of the signal, where the three holes are, about opposite to the top of the signal-disc, when it is in its normal position. The object was so that we could work a series of signals by one battery. And this helped to accomplish it, as follows: In the first place, the track circuit-closer, when it was momentarily closed, it sends a current of electricity from the battery through the wires connected with the large magnet, which vitalizes said magnet and attracts its armature, which causes the lever attached to said armature to raise. When said lever is raised, the retaining lever is drawn forward by a spring, and catches under a projection of the large lever. This retaining lever is held in this position as long as the disc is held in sight, or is visible, or until the train arrives at the point at which they wish to have the signal concealed. At that point there is another track circuit-closer, which has wires connected with the battery, and also with the small magnet attached to the upper black-walnut block. When said track circuit-closer is momentarily closed, it sends a current of electricity through the small magnet, which vitalizes it, when it attracts its armature, which withdraws the lever attached to it from under the projection of the large lever. When this under lever is withdrawn, it causes the signal to fall in its normal position.

These alterations were made at the shop in New Haven. At that time we were having a shop built in Meriden, and it was nearly completed.

(Exhibit No. 5 shown witness.)

I have seen such an arrangement as that exhibits at West Meriden, Conn., in the new shop, I think in January, 1873. It con-
300 sisted of four or five double-circuit instruments, as represented in this exhibit, connected with one battery. The double-circuit instruments were put up on the side of the model-room in the shop, and I think Mr. A W. Hall was there when I saw them the first time. He said to me it was a plan for operating a series of signals by one battery.

I think Mr. Snow was in Boston or Salem at the time I had this

conversation with Alvah W. Hall. To the best of my knowledge, this was the 17th day of January, 1873. We became actively engaged soon after we got moved to Meriden, which was the first of March, 1873, in making these alterations, and were engaged at this employment for the next nine or ten months, I should think; I cannot state positively. Exhibits Nos. 16 and 17 were the two first instruments that were altered over. I think we had them connected with a battery in New Haven, in the shop, after those attachments were put on, to see how they would operate, and whether they would operate or not. They were taken to the shop in Meriden afterwards, and they were put up there and operated in the model-room, where we had the model this Exhibit No. 5 represents. I took the attachment that I have described as being upon Exhibit No. 17, where the three holes are, off from it last week when I took it down.

These instruments, Nos. 16 and 17, were put up in the shop at West Meriden, on some stands for that purpose, in a room in the third story, and in the N. W. corner of said room, in the same room where apparatus shown in No. 5 was put up; they were not so placed until after that was already up. When we came to put up these, I cannot say whether or no there was any change made in the apparatus shown in Exhibit No. 5.

Cross-examined by Mr. PERKINS:

Cross-int. 1. What position have you occupied in the em-
301 ployment of Mr. Hall, or the signal companies with which he has been connected, since your first engagement by him or them?

Ans. I have superintended the work in the shop, all the time, subject to Mr. Hall's wishes.

Cross-int. 2. About how many men, on an average, have there been employed under you?

Ans. I should think it would average about ten.

Cross-int. 3. How do you fix the time when Mr. Hall first spoke to you about actuating a series of signals by one battery, as been in December, 1872?

Ans. I recollect, because it was about the time of our getting ready to move the work to Meriden; I recollect of having some conversation with Mr. Hall about it in December, by the circumstance, that on that day he requested me to write to G. W. Davis & Co. in regard to an engine, and we talked in relation to the engine, and then when Mr. Hall went to the depot I went with him, and during our walk to the depot we conversed with reference to our moving the shop, and various things connected with it, and in that conversation he said to me that he had a plan whereby he could work a series of signals from New York to Boston by one battery, but I don't think he gave me any detailed account at that time how he could work them.

Cross-int. 4. How long were you occupied in getting ready to move from New Haven to Meriden?

Ans. We commenced Monday morning, the first Monday in

March, 1873, and finished at half-past three in the afternoon of the Saturday following.

Cross-int. 5. What was the next thing after this conversation that Mr. Hall said to you about this method of actuating a series of signals by one battery, and how long was it after this first conversation?

Ans. I could not state what the first thing he said to me was, but it was within a week after; when he came to the shop and said he was going to make an experiment. He asked me if I had
302 any materials to set up a battery. I told him that we had a small battery—a carbon battery. He said he would like to have me set it up. I set up the battery as requested, and then he said he wished for me to get some double-circuit instruments like Exhibit No. 3. I got two, I think, and placed them on a small bench, and also got him some small magnet wire, and connected the instruments with the battery, and one instrument with another. Mr. Hall helped to make these connections. One pole of the battery, I cannot say which, was connected with the lower screw on the left-hand side of the face of the instrument, which screw was connected with the raise magnet; the raise magnet is the lower magnet. The other pole of the battery was connected by a wire to the upper left-hand binding-screw, from which we run a branch wire to the upper binding-screw on the right-hand side. We led a wire from the lower right-hand binding-screw, that is, from the lower binding-screw on the right-hand side to the other double-circuit instrument, to the lower left-hand binding-screw on that instrument. I am not perfectly familiar with the wires, and I could not tell just how they were run through, now. They were so arranged, that when we operated our double-circuit instrument, it would operate the other, on the same plan that we operate the signal, to raise it or reverse it.

Cross-int. 6. Cannot you explain more exactly the arrangement of the wires by which you brought this about?

Ans. Not very well at this time.

Cross-int. 7. Have you any means of doing so, except by communication with T. S. Hall?

Ans. I think this Exhibit No. 5 represents the plan by which they were connected, but I have no other means of explaining except by communicating with Mr. Hall.

Cross-int. 8. How long after this experiment was it that you began to work on Exhibits 16 and 17?

Ans. Soon afterwards; I do not know as I could fix the time.

Cross-int. 9. For what were the frames of these exhibits originally made?

303 Ans. They were made for signals, such as they were using.

Cross-int. 10. Had they ever been actually in use?

Ans. No, sir.

Cross-int. 11. What was done with them after you had altered them in the manner you have testified, so far as you knew?

Ans. They were attached to a battery in the first place in New Haven; after that they were taken to Meriden, where they have been since that time.

Cross-int 12. Have they been used for any purpose; and, if so, what?

Ans. They were put on the stands at Meriden and attached to the battery there to show the operation of signals that worked by one battery. Nothing else to my knowledge.

Cross-int. 13. Can you state when they were so placed on the signal stands at Meriden?

Ans. They were placed on the signal stands soon after we moved to Meriden.

Cross-int. 14. How soon after? State as nearly as you can.

Ans. Some time between the first of March and the latter part of April.

Cross-int. 15. Describe as fully as you can, in detail, all the mechanism by which they were so worked at Meriden, beginning with the battery.

Ans. I could not give you a detailed description of all the mechanism which was used to work them.

Cross-int. 16. Did you see them in operation?

Ans. I did.

Cross-int. 17. Did you understand the manner in which they worked?

Ans. I had a general idea of how they worked, but could not give it in detail.

Cross-int. 18. Can you give this general idea which you had?

304 Ans. Not very clearly.

Cross-int. 19. Will you give it as clearly as you can?

Ans. There was a battery which connected with the magnet of the danger signal. When that magnet was vitalized it attracted its armature, and when said armature was attracted it caused the long end of the lever to raise, and the retaining lever was drawn under the projection on said lever by a spring, for the purpose of drawing it forward. When said armature was attracted and the long lever raised, and the detaining lever was in its position, by the action of the rod that connected the long lever with the short lever at the top of the signal, that caused the signal disc to be raised so that it was visible. There were wires connected with the small magnet on the signal to reverse it.

Cross-int. 20. Is that as full a description as you can give?

Ans. That was the general idea that I had of it.

Cross-int. 21. Can you describe the manner in which the signal was worked before you made these changes that you have mentioned on your direct examination?

Ans. I could not.

Cross-int. 22. Can you tell how the one method differed from the other?

Ans. I could not, with the exception that one was worked by one battery, and the other by a number of batteries.

Cross-int. 23. How many batteries were used in the other method to work one signal?

Ans. I could not state.

Cross-int. 24. From whom did you get directions and plans to

make the changes on Exhibit 16, which you have mentioned in your direct examination?

Ans. Directions from Mr. Hall, and plans as far as we had any; we had perhaps a little sketch.

Cross-int. 25. Who made that little sketch?

Ans. If we had any Mr. Snow made it.

305 Cross-int. 26. Do you know whether you had any or not?

Ans. I could not state positively whether we had any or not. It did not require much of a plan, as it was a part of a double-circuit instrument; we had the idea.

Cross-int. 27. What was the difference, if any, between the apparatus, at the lower part of Exhibit No. 16, and a double-circuit instrument?

Ans. Well, there may be a difference in mechanical construction, but the object required was the same, as I understand it.

Cross-int. 28. Then, if I understand you, what you did was substantially to put a double-circuit instrument on the lower part of the signal frame?

Ans. Yes, sir; making a signal instrument out of the double-circuit instrument.

(The cross-examination being now read over to the witness, he desires to correct his testimony in answer to cross-int. 3, by saying: The first of the conversation happened in the shop, in relation to what Mr. Hall said to me about being able to work a series of signals by one battery, and then we talked of the same subject again, the same day, as we walked down the street to the depot, as I stated before.)

In relation to his answer to cross-int. 4, he says: That he meant by "moving," the actual moving of the machinery, etc., but they had been getting ready to move, and he had been going back and forth to the new shop in Meriden since the first of December, 1872.

Cross-int. 29. You have said that some time after the conversation between you and Mr. Hall, he gave you directions for making these changes on Exhibit 16. State as fully as you can all that he said to you, relating to such changes.

306 Ans. I could not state what he said, I could only give you the general results; what was accomplished. The results were what shows on Exhibits 16 and 17.

Cross-int. 30. Can you not state any of the directions he gave you, or conversations he had with you, in consequence of which you made these changes?

Ans. I could not at this time.

Cross-int. 31. Did you make these additions yourself, or were they made by workmen under you?

Ans. They were made by myself and Mr. Snow.

Cross-int. 32. Did Mr. Snow give you any information or directions in regard to them?

Ans. I should say he did.

Cross-int. 33. Can you tell what directions were given to you by Mr. Hall and what by Mr. Snow?

Ans. What I mean by directions is, we talked of how we had better make it: the general directions were given by Mr. Hall.

Cross-int. 34. Can you explain how the changes you made in Exhibits 16 and 17 enabled any one to work several signals by one battery?

Ans. Nothing further than I gave in my direct testimony.

Cross-int. 35. In what part of your direct testimony did you explain how these changes enabled a series of signals to be worked with one battery?

Ans. When I was describing how the signal was worked by the track circuit-closer I believe that I stated that the track circuit-closer was connected with the battery and magnet, and what I testified to in connection.

Cross-int. 36. After these Exhibits 16 and 17 were altered over were they worked in the shop at New Haven?

Ans. They were.

Cross-int. 37. Were any more than these two signals worked by one battery at New Haven?

Ans. No, sir; It was all we had changed at the time we were there.

307 Cross-int. 38. Were any more than these two signals worked by one battery at the shop at Meriden?

Ans. Not to my knowledge.

Cross-int. 39. Do you know whether or not, by the method used before these exhibits were altered, two danger and safety signals, such as these originally were, could be worked by one battery?

Ans. We could not, as I understood it.

Cross-int. 40. Can you state why not?

Ans. I am not an electrician, and I should be unable to state why not.

Cross-int. 41. In your opinion, under the former plan, would each of these two signals need a separate battery to work them?

Ans. In the idea that I had of it, it did.

Cross-int. 42. Then, as you understood Mr. Hall, what he had discovered was a way of working a danger and safety signal both by one battery, was it?

Ans. The idea that I had from Mr. Hall was that he had discovered a way of working a series of signals from one battery.

Cross-int. 43. Do you consider that an answer to the question?

Ans. Yes, sir. It might consist of two or more.

Cross-int. 44. Will you explain how the changes you made, as shown in Exhibits 16 and 17, could avail in working more than one safety and one danger signal?

Ans. I could not.

Cross-int. 45. Did you understand Mr. Hall that the method he had discovered of working a series of signals by one battery consisted in the changes you made, as shown in Exhibits 16 and 17?

Ans. I understood Mr. Hall that it was necessary to make these changes, in order to work a series of signals from one battery.

Cross-int. 46. Did you understand from Mr. Hall that any other changes besides those were necessary; and, if so, what?

308 Ans. To the best of my knowledge I do not think he did say that it was necessary to make other changes.

Cross-int. 47. So far as you learned from him then these changes constituted the method of working several signals with one battery that he had discovered?

Ans. As I understood Mr. Hall, he could work his signals by those changes made in Exhibits 16 and 17.

Cross-int. 48. Can you not answer the last question directly?

Ans. I do not know as I could answer it any more direct than that.

Cross-int. 49. What did you understand from Mr. Hall to be the method by which he could operate a series of signals from one battery?

Ans. I do not know as I could answer that question.

Cross-int. 50. Do you know in what way the double-circuit instrument was used before this change was made in these signals, as shown in Exhibits Nos. 16 and 17?

Ans. It locked the lever that had the armature connected with the raise magnet; that is, I so understood it.

Cross-int. 51. Is not that the same thing as is done by the change you speak of, as shown in Exhibit 16 and 17?

Ans. I do not understand it so. No, sir. I understand that when the raise lever is locked on the double-circuit instrument that a current of electricity is kept passing through the magnet, so that this magnet on the signal, Exhibit 16 and 17, is held vitalized so long as this disc is displayed. That is the idea I have of it.

Cross-int. 52. Then, is your idea that in both methods a lever is locked, but that there is a difference in the current of electricity after it is locked?

Ans. The idea that I have of it is that one lever is locked and a constant current of electricity passes through it and through the large magnet on Exhibits 16 and 17, and the disc is held visible by that current while it is passing through it. That is the old style before the alteration. After the alteration a *momentary* cur-

309 rent vitalizes the magnet and attracts the armature and causes the long end of the lever to raise.

When that is so raised the retaining lever is drawn under or forward by a spring for that purpose, and that holds the signal in position instead of a constant current of electricity, as in the old plan, and it so holds the signal in position so long as it is required, and when the reverse track circuit-closer is closed it sends a current of electricity through the small magnet on the black walnut block, attracts the armature attached to the retaining lever, and withdraws from under the projection, and the disc drops to its normal position.

Hearing adjourned to June 20, 1877, 10 a. m.

NEW HAVEN, *June* 20, 1877, 10 *a. m.*

Cross-examination of CHARLES H. MANSUR resumed.

Parties represented as yesterday.

Cross-int. 53. In what way do you fix the date of January 17th, 1873, when you saw apparatus on the walls of the model room at West Meriden?

Ans. I went to Meriden that day on business connected with the shop, and while there reboxed and shipped some instruments to the Eastern R. R. Co.

Cross-int. 54. How do you know it was that day when you so reboxed and shipped instruments?

Ans. There was a little memorandum made of it on an old memorandum book I had.

Cross-int. 55. Where is that memorandum book?

Ans. I believe that I have it at home now.

Cross-int. 56. When did you see it last?

Ans. I could not say positively when I did see it last, but I should think within the past two months.

Cross-int. 57. When did you last see this memorandum in the book that you speak of?

310 Ans. It must have been within that time I stated, as I was looking over the book.

Cross-int. 58. Can you state when it was when you saw Exhibits 16 and 17 put in use in Meriden, as you stated in the last part of your direct examination?

Ans. Some time in the latter part of March, or in April, 1873.

Cross-int. 59. Did you see the signals worked at that time in connection with the wires on the walls of the model room?

Ans. I could not state whether they were connected with the wires on the walls of the model room, or only with the battery wires.

Cross-int. 60. At that time were there any other signals made similar to Exhibits 16 and 17?

Ans. No, sir; there were not.

Cross-int. 61. How long after that was it that additional signals, of a similar character, were finished, ready for use?

Ans. We commenced soon after that—I should think some time in April, 1873—making signal instruments, such as are now used for working signals with one battery. I could not state how soon there were any finished, ready for use.

Cross-int. 62. Were the additional signals so made like Exhibits 16 and 17 in all respects?

Ans. The general principle was the same; there might have been some little difference in the mechanical construction of them.

Cross-int. 63. Can you describe any such differences in the mechanical construction?

Ans. There was a difference in the long rod that connected the two levers on the signal. In these exhibits the rod is a continuous rod; in the signals afterwards made the rod was in two parts, about eight inches of the rod in the middle part was hollow, and contained a spring with sufficient power to hold the signal in its raise

311 position. The lower part of this hollow part of the rod was slotted, the slot being about $\frac{3}{8}$ of an inch long; then the remainder of the rod went into the hollow portion of the rod, and rested on this spring; then there was a pin went through the rod

and worked in this slot in the hollow portion of the rod. When the armature of the large magnet was attracted, it compressed this spring in the rod, and the spring was of such power as to raise this disc into its raise position, and hold it in that position until it was reversed.

Cross-int. 64. State, as nearly as you can, when the first hollow rod and spring, which you have described, was commenced to be made?

Ans. It was made some time in the summer of 1873. I think about the middle of the summer.

Cross-int. 65. Were any other signal instruments, with the continuous rod, as on Exhibits 16 and 17, before this hollow rod was adopted?

Ans. Not of this kind of rod, that acted as a spring.

Cross-int. 66. Were there of any other kind than these two?

Ans. There were; simply a straight rod, made large enough to be stiff; and when the armature on the larger magnet was attached, the circuit would have to be closed long enough to raise the signal disc into its raise position.

Cross-int. 67. What was the difficulty sought to be overcome by substituting the hollow rod and spring for the continuous rod?

Ans. In using the hollow rod, you could operate the signal by using the momentary current for closing the circuit. In using the stiff rod, the circuit would have to be held closed longer.

Cross-int. 68. Can you state who suggested the idea of substituting the hollow rod and spring, for the continuous rod.

Ans. Mr. Snow first spoke to me about it.

Cross-int. 69. Can you state about how many signals were ever made with such continuous rod.

312 Ans. If you mean stiff rods, two or three hundred, more or less; I cannot say positively.

Cross-int. 70. Were these two or three hundred made with a retaining lever, substantially like Exhibits 16 and 17?

Ans. They were not; there was no retaining lever attached to the signal.

Cross-int. 71. When were these two or three hundred made?

Ans. In the years 1870, '71, and '72.

Cross-int. 72. Can you state whether any signals like Exhibits 16 and 17, with a continuous rod, were made after those exhibits were made; and, if so, about how many, and when?

Ans. There were no signals made with a continuous rod, after Exhibits 16 and 17 were changed to their present shape.

Cross-int. 73. Do you know whether any signals like Exhibits 16 and 17, containing a continuous rod like them, were ever actually used on any railway, or elsewhere?

Ans. No, sir; not to my knowledge.

Cross-int. 74. State as nearly as you can when the first signal, like Exhibits 16 and 17, but containing a hollow rod and spring instead of a continuous rod, was actually finished so as to be capable of operating?

Ans. Some time in the summer of 1873; the middle of the summer, to the best of my recollection.

Cross-int. 75. Have you any means of fixing the time more accurately?

Ans. I have not.

Re-examined by Mr. BALDWIN:

Re-E. 76. In your answer to cross-int. 3 you state that you recollect your first conversation with Mr. Hall about the new one-battery system took place on the day when he asked you to write to Davis & Co.; did you write to them as requested?

313 Ans. I did, sir.

Re-E. 77. Have you a copy of that letter?

Ans. I have not. I may have their reply at Meriden. I did have it a year or more ago.

Re-E. 78. Will you look it up and annex it to your deposition?

Ans. I will.

Re-E. 79. In your answer to cross-int. 19 you describe the working of the danger signal in the shop at Meriden in the spring of 1873. Was that the only signal worked in that connection?

Ans. They had a safety signal that worked in connection with the danger signal.

Re-E. 80. In your answer to cross-int. 85 you say that you cannot say how many batteries were used in the other method. What did you mean by the "other method"?

Ans. By the "other method" I meant the way they were worked by several batteries, the old style or old way of working them. I did not mean to be understood to say that I did not know how many batteries it took to work one signal; but the idea I had of the question was, that it was how many batteries were used to work the old signals, and the instruments connected with them.

Re-E. 81. In your answer to cross-int. 46, changes in what did you refer to in using the word "other changes"?

Ans. I referred to changes made in Exhibits 16 and 17.

Re-E. 82. You stated yesterday that Exhibits 16 and 17 were used for experimental purposes at West Meriden after their alteration. Did you mean to change that testimony by your answer this morning to cross-int. 73?

Ans. What I mean by saying that I had no knowledge of the use of these two signals was, that I had never seen any such actually used, except these two for experimental purposes at Meriden and New Haven, as I have stated.

Re-E. 83. In your direct testimony on pages 73 and 79 you made use of the word "relay." What meaning did you attach to it?

314 Ans. I meant that there were other wires connected with it. I refer to page 78. On page 79 I meant that there were circuit-closers with which other wires might be connected.

Re-E. 84. In your answer to cross-int. 2, page 82, what period did you refer to as that during which there has been an average of ten men under you?

Ans. I referred to years 1871, 1872, and 1873. Not since Mr.

Hall has been sick. Since that there have not been so many. Mr. Hall was taken sick in the winter of 1873–'4.

Further examination of Mr. Mansur adjourned to June 21, 10 a. m.

THOMAS S. HALL, sworn, and examined by Mr. BALDWIN:

My name is Thomas S. Hall; my age is fifty years; residence in West Meriden, Connecticut; and my occupation is general manager, secretary, and treasurer of the Hall Railway Signal Company; that company was formed in November, 1873, and I have been general manager ever since. From March, 1867, I have been exclusively engaged in inventing, experimenting upon and perfecting electric machinery, utilizing electricity, and electro-magnetism, and applying the same to the art of railway signaling automatically and otherwise, together with the management of the companies represented by me in this special line of business.

I took out my first patent for electro-magnetism, applied to railway signaling, February 26, 1867, which is numbered 62414.

(Copy of patent put in evidence and marked Exhibit 18, E. E. M., Ex'r, June 20, 1877.)

My attention was first called to the subject of electro-magnetism, as applied to railway signaling, in the year 1865 or early in 1866. I commenced expeaimenting quite extensively in 1866. I made my first practical application of my system of automatic sig-
315 nals, as they then were, to the New York & New Haven R. R., at Stamford, Conn., late in the fall of 1866. I continued my experiments, perfecting my device, a considerable portion of my time, from that time until March, 1867. There was an exhibition of my apparatus made at the Paris Exposition of 1867. I commenced the construction of the model there exhibited, I should say, some four to six months prior to the exposition. To be more specific, in January, 1867, I had the model in process of construction.

The first company that was organized to manufacture my patent was Hall's Patent Electric Railway Switch and Drawbridge Signal Company, and was organized April 3, 1868, and was located at Stamford, Conn. The president of the company was Hon. Wm. T. Minor, of Stamford. My connection with that company was that of general agent and a director. The name of this company was afterwards, in the year 1870, changed to that of The Electric Railway Signal Company, and after this change of name it did business at 18 Howard street, New Haven, with shops on corner of Howard street and Whitney avenue. I remained connected with this company, in the said capacity, until the present company, the defendant company, was organized, as before stated.

The first mentioned company issued a circular descriptive of their device and system, which I now hold and present.

(Defendants place in evidence the circular referred to, which is marked Exhibit No. 19, E. E. M., Ex'r, June 20, 1877.)

This was published in 1868. One thousand copies were printed,

and they were circulated among railway men and those interested in such matters. The edition was entirely used up in this way, with the exception of two or three. The first application of my apparatus at Stamford was made to a switch, in November or December, 1866. It was my device, as described in my patent, Exhibit No. 18. A very few months after this application, and before I patented my visual signal, I applied a visual signal at Stam-
316 ford, in connection with the application before named. I was constantly experimenting from March, 1867, with visual and audible signals, until I so far perfected the devices that, upon examination of the same by Wm. D. Bishop, president of the New York and New Haven R. R., and the late James H. Hoyt, superintendent of the same road, I received an order from President Bishop to apply visual and audible signals to a switch near Stamford depot, and the draw-bridge at Bridgeport. These applications were made in 1867, and I was paid by the New York and New Haven R. R. Co. for making the same. They were seen and examined by I. C. Buckout, superintendent New York and Harlem R. R. Co., and Prof. R. Ogden Doremus, of New York city. My inventions aforesaid were described in the New York Tribune, of April 3, 1867; the Scientific American, of May 4, 1867; and the American Journal of Mining, of May 2, 1868.

(Defendants lay in evidence copy of patents dated June 1, 1869, No. 90743 and 90744, which are marked, respectively, Exhibits No. 20 and 21, E. E. M., Ex'r, June 20, 1877.)

I invented the subject of these patents in 1868 and 1869.

The object of the patent represented in Exhibit No. 20 was to operate one or more signals automatically, in connection with a draw-bridge, by the withdrawal of the key, which secures the draw-bridge in a safe position. I arranged two pairs of circuit-closers in each box, as shown in the drawing accompanying the patent, to operate signals at both ends of the bridge. By Exhibit No. 21, I patented a device for the purpose of operating, automatically, one or more signals in connection with a switch.

In the spring and summer of 1868, I erected signals on the Morris and Essex R. R., commencing at Hoboken yards. This line extended some ten miles from Hoboken, through Newark, including a draw-bridge at Newark; all of which work amounted to some $6,000, which I was paid.

317 In the winter of 1858–69 I invented a device which I called my double-circuit instrument. The object of said invention was to enable me to operate a series of signals at highway crossings, and at other points, where I might desire to apply them, on the line of a railroad, by utilizing one or more batteries in connection with signals. Said invention was patented December 7, 1869, and numbered 97505.

(Defendants place in evidence copy of patent referred to, which is marked Exhibit No. 22, E. E. M., Ex'r, June 20, 1877.)

My first practical experiment with this device was made on the

New York and New Haven R. R., at or near Stamford station, Conn., I think in the autumn of 1868, or very early in the season of 1869. I will describe it as follows:

I used two telegraph wires, which terminated at the station at one end, to which was attached a battery, including what I term a raise magnet of my double-circuit instrument. Then wires were extended to a place on the road called New Hope, I should say at least 1½ miles from the station. I had a circuit-closer placed on a post, specially set for that purpose, close to the track. From the circuit-closer there was an arm extended over the track, sufficiently far to come in contact with an iron post, which was secured to the top of the cab of the locomotive. To this circuit-closer was attached the extreme end of the telegraph wires. This circuit-closer was so constructed that when its arm extended over the track the metallic points were disconnected and the circuit left open. They were held in that position by means of a spring. Whenever the arm of this circuit-closer came in contact with the iron arrangement on the top of the cab of the locomotive the circuit would become momentarily closed. There were two divided anvils and a metallic plate, that extended between them in such a way that when the circuit-closer was in its
318 normal position this metallic plate would not come in contact with either of the anvils. Whenever this circuit-closer was operated upon by the arrangement fixed on the top of the locomotive this metallic plate would come in contact with both the divided anvils. The two telegraph wires being connected with the top ends of the two anvils, respectively, and extending to the station with which the battery was connected, including the raise magnet of my double circuit instrument, by the changing of the circuit-closer which connected these divided anvils an electric current would flow from the battery through the telegraph wire to and through the divided anvils, and back by a metallic return to the raise magnet B B of the double-circuit instrument, momentarily vitalizing the same, and by attracting its armature causing the spring lever marked F F in the drawing, forming part of the Exhibit No. 22, to take its retaining position as a detent in the double-circuit instrument. The effect thus produced would continue, notwithstanding that electro-magnetism had only been momentarily brought into use by the action of the locomotive.

I had a circuit-closer set on a post, which was set near the Stamford station. This second circuit-closer was precisely the same as the one I have just described.

There was a third wire connected with the battery at the station, and also a branch wire connected with a small magnet, marked E in the Exhibit 22. There was an armature marked D, connected with the retaining lever marked F F, said armature being placed in close proximity to the small magnet.

Wires also extended from this small magnet to the two divided anvils of the circuit-closer last named, which, I have stated, operated on the large magnet B B. The operation would be as follows: Whenever the arm of the circuit-closer came in contact with the iron arrangement placed on the top of the locomotive, the divided

anvils would become electrically connected, the electric current would instantly flow from the battery, to and through the
319 points connected by the metallic plate, back to the small magnet, which would become thereby vitalized, and the retaining lever F F would be withdrawn by the electro-magnetism operating on the armature D, and the signal instrument be left in its normal position.

This instrument was enclosed in a box in the freight depot. I asked the late James H. Hoyt, the superintendent of the New York & N. H. R. R., at what rate of speed did he run his trains from New Hope to Stamford station. His answer was, 30 to 35 miles per hour. I stated to him that he was mistaken; that it was 50 miles per hour, sometimes 60, or nearly that. He asked me how I knew that fact. I invited him to meet me at the freight depot, at an hour when trains were approaching, and that I would tell him while in the depot.

He met me by appointment, and I requested him to hold his watch, and I unlocked the case containing the double-circuit instrument. I asked him to note the exact time when that instrument was set, and also the exact time when it was reversed. He did so. I explained to him the place where the instrument was first operated upon at New Hope, and also the spot where it was reversed. Taking the measurement between these two points, he soon ascertained, by the time it did take the trains to run said distance, that I was quite correct as to the rate of speed I had given him.

(Defendants give in evidence patent, dated May 17, 1870, No. 103,174, which is marked Exhibit 23, E. E. M., Ex'r, June 20, 1877.)

I invented the device shown in this Exhibit No. 23 in 1868, and perfected it in 1869.

(Defendants give in evidence patent dated July 19th, 1870, No. 105,447, which is marked Exhibit No. 24, E. E. M., Ex'r, June 20, 1877.)

I invented the device shown in Exhibit F, being a visual signal instrument, in the winter of 1866, and during the early part of the season of 1867 perfected it.

320 An interference was declared in regard to it between one Thomas Hall, of Boston, and myself, that involved a long delay, I should think two years, between the application for and the issue of the patent.

I invented the device shown in Exhibit No. 24 in 1868 or 1869, and used it on the Morris & Essex R. R., but was engaged in perfecting it up to the time of my application for a patent. I made it a point in all my inventions to put them into practical operation, and to become satisfied as to their practical utility in accomplishing the object desired, before making applications for the pattents. In many cases I have filed caveats before bringing them into practical use.

Before describing my application made at the crossing near Stamford, as shown in Exhibit 1 A, I wish to state that the inventions

represented by patents 97505, 103,174, 103,785, 105,447, were invented as requisite means for the application shown in Exhibit 1 A and other applications pertaining to the science of railway signaling.

Exhibit No. 1 A correctly represents an application I made at Stamford, Conn., in 1869. I was present in New York when Alvah W. Hall explained this diagram, and heard his testimony, and have also since carefully read his testimony, as printed on pages 2, 3, and 4 of the defendants' printed testimony in this case, and his explanation of this application and diagram is correct. I explained this invention and application to said Alvah W. Hall in all its details in 1869.

The invention attracted very great attention. The Stamford application was examined by very many prominent persons; amongst them was Geo. B. Prescott, electrician of the Western Union Telegraph Co.; the late James H. Hoyt, then superintendent of the N. —. & N. Y. H. R. R. Co.; the Hon. Wm. D. Bishop, president of said company; E. M. Reed, the superintendent of the Hartford & N. H.
R. R. Co.; J. Murray Fairchild, of New Haven, then manager
321 of the Western Union Telegraph Co. office at New Haven; H. Kittendorf, master mechanic of the New York and N. H. R. R. Co.; I. Pressey, supervisor of the New York & New Haven R. R.; Jesse H. Lord, the mechanical editor of the Scientific American, and Walter O. Lewis, electrician, of New York city.

The principal of operating any number of signals by the use of one battery, and the requisite mechanism for doing the same, with very slight combinations or modifications, were, in my opinion, embodied in this one application, shown in Exhibit 1 A. In fact, two signals, or their equivalent, a double-circuit instrument, and an audible signal were operated in this application by the movements of trains, at no less than nine different points, in connection with one battery.

Hearing adjourned to June 21, 1877, at 10 a. m.

NEW HAVEN, *June 21st*, 1877.

Parties represented by counsel, as before.

CHARLES H. MANSUR recalled, and examined by Mr. BALDWIN:

Re-E. 85. Have you looked up that letter from Davis & Co., which I requested you to look for and annex to your deposition yesterday?

Ans. I have, and here it is.

(Defendants place in evidence the letter presented, which is marked Exhibit 25, E. E. M., Ex'r, June 21, 1877.)

Re-E. 86. Does that letter enable you to fix any more definitely the date of that conversation which you had with Mr. Hall, in which the one-battery system was first suggested to you by him?

Ans. It does. The conversation was held on Saturday,
322 which was the 21st day of December, 1872, late in the afternoon, and as I wished to write a friendly letter as well as a business letter to Mr. Rollins, the member of the firm to whom the

letter was directed, I did not write the letter until Sunday, and dated it Monday, the 23d.

Re-E. 87. In regard to your answer to cross-int. 53, do you wish to make any correction?

Ans. I would state that I did not ship the instruments; I only reboxed them. Alvah W. Hall said he would ship them if I wished to take the next train to New Haven.

Cross-examined by Mr. PERKINS:

Cross-int. 88. Have you any other means of determining, except from your recollection, that the day of this conversation with Mr. Hall was the day before you wrote to Davis & Co.?

Ans. I have no means of fixing it except from my memory.

CHAS. H. MANSUR.

Subscribed and sworn to this 21st day of June, 1877, before me.

EDWIN E. MARVIN, *Ex'r.*

Examination of Mr. T. S. HALL resumed.

In addition to this application, made near Stamford in 1869, I made other similar applications on the same road; and I had, previously to making these applications, equipped a draw-bridge at South Norwalk with my device. My time was occupied during the winter of 1869–'70 in making improvements in some of the mechanism pertaining to my invention. The 20th of April, 1870, I removed both my residence and business from Stamford to New Haven. I procured a reissue of patent No. 62414 in the early spring of 1870.

323 (Defendants place in evidence copy of reissue referred to, which is marked Exhibit 26, E. E. M., Ex'r, June 21, 1877.)

Early in May of 1870 I employed the firm of Snow & Coe, machinists, of New Haven, to manufacture suitable tools, and to assist me in improving the mechanism of some parts of my inventions.

I think either in May or June, 1870, I contracted with the Hartford & N. H. R. R. Co., selling them the right of using my inventions as they then were, and all improvements that I might make in future pertaining to the same subject. In this contract was embodied a contract on their part to make that season six applications of my signal system at different points on the line of their road.

These applications I made and put into practical use in the fall of that year. This machinery was manufactured at the shops of Snow & Coe, by my directions and under my personal supervision.

One of the applications—the first of the applications made—was at Cedar Hill, near New Haven, at or near the junction with the Air Line R. R.

The mechanism used in this invention consisted of two track circuit-closers, a double-circuit instrument, a visual and audible signal; also two batteries. The visual signal was properly arranged in a house to show danger or safety to the engineer and fireman on the Air Line R. R. when approaching the junction, which would be com-

ing toward New Haven. The track circuit-closer which set this visual signal at danger was placed not less than half a mile from the signal on the Hartford and New Haven R. R., and connected with the track leading into New Haven. The second track circuit-closer, which set the visual signal at safety, was placed near the house that contained the signal, at or near the junction. There was an audible signal placed on a signal post some distance from the visual signal—
I should say about 1,000 feet. The object of this audible sig-
324 nal was to notify the switch-tender at the junction, by night or by day, when a train was approaching on the Hartford and New Haven road.

The two track circuit-closers of this application, which operated these signals, were connected by suitable branch wires, leading from the track circuit-closers at the extreme end of the section to two telegraph wires; these telegraph wires being erected on telegraph poles, and connected with a battery and the raise magnet of the double-circuit instrument, and also with the battery to which the double-circuit instrument and the audible signal were directly connected. There was a circuit-closer connected to the double-circuit instrument, to which circuit-closer were attached two wires. These wires were connected to the second battery and also to the magnets of the visual signal, which was arranged in a suitable case, and placed on top of the signal house. A train approaching the junction on the Hartford and New Haven road, when its wheels came in contact with the track circuit-closer, placed at least one-half mile from the junction, and from the visual signal, would momentarily close the circuit through the battery and the raise magnet and the double-circuit instrument, and also at the same moment close a secondary circuit on the double-circuit instrument, from which two wires extended to the audible signal, placed about 1,000 feet distant on the lide of the road, near the switchman's shanty. By means of the circuit-closer, which I have already described, as being attached to the double-circuit instrument, and being connected by two wires, with the secondary battery, that I have described, and the raise magnet of the visual signal, a circuit would at the same moment be completed, vitalizing the magnet of the visual signal, thus attracting its armature. This would cause the visual signal to show danger.

By the working of this system, it will be seen that by momentarily closing a circuit, by a track circuit-closer, placed not less than a half
mile distant from the audible signal, the raise magnet of the
325 double-circuit instrument was vitalized. This raised and locked in position the lever of a double-circuit instrument, and an audible signal was at once put in operation, which continued to operate, and a visual signal also displayed, which continued displayed until the train had reached the circuit-closer attached to the track of the first-named circuit-closer. The circuit-closer thus reached by the train is called the reverse track circuit-closer, and to it was connected two branch wires, which were connected with the first-named battery and the reverse magnet of the double-circuit instrument.

When the wheels of the train came in contact with the last-named

track circuit-closer a momentary current of electricity would pass through it and the branch wire connected with it, the battery, and the last-named magnet, momentarily vitalizing the same, which would attract the armature connected with that magnet.

This armature, when attracted, would withdraw the retaining lever, which would instantly open the circuits which had been formed through the magnet of the audible signal, and also the visual signal, which would cause the visual signal to change to safety by gravitation and the audible signal to cease sounding, leaving both in their normal condition.

In this application were embodied such mechanism and the wires were so arranged and connected as to substantially operate three signals by one and the same battery.

Two signals, or their equivalent, the double-circuit instrument and the audible signal, being placed at different points on the line of the R. R., and being connected with the raise and reverse circuit-closers, as described, were actually operated by one and the same battery.

In this application the secondary battery, described as being connected with the circuit-closer on the double-circuit instrument, and the raise magnet of the visual signal were suitable mechanical arrangements for operating the same, and were substantially
326 the same, with slight mechanical variations and combinations, that I now use for operating a series of signals, placed on the line of a railroad, and operated by one and the same battery.

The second application, which I made on the line of the Hartford & N. H. R. R., is represented by a diagram which I now hold.

Defendants place in evidence the diagram referred to, which is marked Exhibit 27, E. E. M., Ex'r, June 21, 1877.

The plan of application, as shown by Exhibit No. 27, correctly represents an application which I made at Wallingford, to the Hartford & N. H. R. R., at and about the same time that I made the application just described as being made at Cedar Hill.

There was, in addition to what is represented on this plan, a visual signal connected therewith, precisely as I have described in the application at Cedar Hill. There was also in connection with both of the double-circuit instruments, shown on this plan, a secondary application, with a visual and audible signal, placed at another crossing from the one represented on the middle of the exhibit near the battery. In the application illustrated by this exhibit there were four track circuit-closers placed at different places upon the tracks; there were two double-circuit instruments and an audible signal, all connected to and operated by one battery. The mode of operation of the apparatus represented by this exhibit was very similar to that of the apparatus at Cedar Hill, except that this application was made to the two tracks of a double track railroad. The second application at Wallingford at the other highway was operated by the raise and reverse track instruments, represented in this diagram, Exhibit No. 27, through the circuit-closers connected with the two double-circuit instruments, which are shown above the

327 battery in the diagram. It consisted of an audible signal attached to a post near the crossing, and was connected with an independent battery.

I cannot state positively when this diagram, Exhibit No. 27, was made. It is a photo-lithograph from an ink drawing, made by Osborne's process. According to my best recollection, the ink drawing was made either in 1871 or 1872. The description which I have given of the application at Cedar Hill and Wallingford, correctly represents the other applications made about the same time, two being made in Meriden, one near Newington, and one at Park St. crossing, near Hartford.

The same year I made four applications to the Flushing & North Side R. R. on Long Island, similar to those described.

(Defendants place in evidence circular of the Electric Railway Signal Co., entitled "Hall's System of Automatic Electric Railway Signals," which is marked Exhibit No. 28, E. E. M., Ex'r, June 21, 1877.)

(Counsel for complainant objects to the introduction of this exhibit in evidence, as immaterial, and especially inadmissible as proof of any facts or statements referred to or contained therein.)

The Electric Railway Signal Co. published this circular in the year 1870. There were not less than 1,000 copies published, and a large portion of them distributed among railroad officials and others interested in the science of automatic railway signalling. I have but a few of them left.

In the spring of 1871 I got out a new patent, numbered 113,425.

(Defendants place in evidence copy of the patent referred to, which is marked Exhibit No. 29, E. E. M., Ex'r, June 21, 1877.)

328 In April or May, 1871, I had an interview with the late Commodore Vanderbilt on the subject of my Automatic Electric Railway Signal System. He gave orders to Wm. H. Vanderbilt, vice-president, and J. M. Toucey, sup't of the Hudson R. R. R., to give my matter their attention. A very few days after this Mr. Toucey visited New Haven and made a thorough examination of the system at Cedar Hill. He also visited Meriden, and examined at least one of the applications made there. I was requested by him to set up models of my device, representing as nearly as possible the practical utility of my various inventions. Within a short time I put my models in operation in a building on 4th ave., not far from 28th street, New York city.

The device was examined by Wm. H. Vanderbilt, vice-president; the late J. C. Buckhout, then sup't of the Harlem R. R. and the Grand Central depot; J. M. Toucey, sup't of the Hudson R. R. R.; together with several prominent Western railroad gentlemen whom I am not now able to name.

There were several scientific gentlemen who made an examination of the system at the same time, among them the late Prof. S. F. B. Morse, Prof. R. Ogden, Doremus, and George B. Prescott, electrician of the Western Union Telegraph Company. Up to this time there

had also been in my employment, in one way or another, a number of persons who had assisted me in manufacturing my signal instruments and in erecting my work on the lines of railroads, who, by such employment, had become more or less acquainted with my inventions. Among them was Stephen C. Hendrickson, one of the plaintiffs in this case, who made application to me, through Mr. Samuel C. Bishop, a manufacturer of insulated wire and gutta-percha goods, for employment, in 1868, and stated that he was accustomed to putting up telegraph lines for the Western Union Telegraph Co., and had worked at it a great length of time.

329 I employed him to put up my lines on the Morris & Essex R. R. in 1868. The same year I made an application to one or two draw-bridges, near Flushing, L. I., on the Flushing & Northside R. R., in which he was also employed. In 1869 I employed him to run the wires for our line on the New York & N. H. R. R., near Stamford.

He worked a while at Stamford on the application described in Exhibit 1 A.

While thus engaged in running my telegraph wires and assisting in putting up my batteries, connecting the wires to the double-circuit instruments and signals, he became familiar with the details of my inventions. At the time of erecting these signals of the New York & New Haven R. R. at Stamford, in 1869, Stephen C. Hendrickson being engaged in the work, from information which I received I was led to suppose that he was engaged, with others, in attempting infringements upon my patents. As soon as I received this information I sent for him to meet me at the Stamford depot. I asked him if it was true that he had taken my double-circuit instrument, and other devices of my invention, to Mr. Frank L. Pope's office, in Broadway, New York, and if they were engaged in getting up devices that would be an infringement upon the same. He did not answer the question which I asked him directly, but replied as follows: "Have not I as good a right to invent railroad signals as you or any one else?" I said "Possibly you have, but not when you are employed by me. You certainly have no right to infringe upon my patents, or to take my instruments to other parties to experiment with." I again asked him directly the question that I had previously asked him. He did not deny it. I then stated that I should take it for granted that it was true, that I simply considered him an unmitigated scoundrel, and requested him to leave my employment, and never again to apply to me for a day or an hour's work. I paid him for his services up to that hour, and have not employed him since.

330 On the 31st day of May, 1871, I made a contract with Wm. H. Vanderbilt, vice-president of the New York & Harlem R. R. Co., and received a check from the treasurer of said Co., to the amount of $8,000, for a license to use my improved system of electric railway signals, together with all future improvements that I might make pertaining to the subject.

I was, at the same time, employed by Wm. H. Vanderbilt, vice-president, to engineer and superintend the construction and appli-

cation of my improved system of signals, at the Grand Central Depot at New York, and other places, at which they might apply the same, on the Harlem R. R. Mr. Vanderbilt agreed to pay me, and did pay me, for my services, at the rate of $5,000 a year, while the system was being applied.

I began work at once under the contract, manufacturing the instruments at our shops in New Haven, and also to ascertain the requirements at the Grand Central Depot, and making plans for applying the system.

I used in this work several of my inventions, which were not yet patented, which I was engaged in developing or patenting. I took out during the summer the following patents:

Reissue No. 4493, dated August 1, 1871, for improvement in double-circuit instruments.

Also, No. 118,606, dated August 29, 1871, for improvement in signal apparatus.

Also, No. 119,137, dated September 19, 1871, for improvement in signals.

On December 12, 1871, I also took out patent No. 121,870, for improvement in signal houses.

(Defendants' counsel place in evidence copies of the patents named, which are marked respectively as follows:

No. 4493, marked Exhibit 30, E. E. M., Ex'r, June 21, 1877.

331 No. 118,606, marked Exhibit 31, E. E. M., Ex'r, June 21, 1877.

No. 119,137, marked Exhibit 32, E. E. M., Ex'r, June 21, 1877.

No. 121,870, marked Exhibit 33, E. E. M. Ex'r, June 21, 1877.

I will state that it was distinctly understood between myself and the officials of the three railroad companies, that I had licensed up to that time: 1st. The New York and New Haven R. R. Co., Wm. D. Bishop, president, licensed, May 26, 1870; next, the Hartford and New Haven R. R. Co.; also the New York and Harlem R. R. Co.; that many of the devices used in my signal system were not then patented, but were in process of being patented, and I licensed them to use all the patented improvements that we then had, or might have, pertaining to the improvement, in future.

Exhibit No. 2 shows only a part of the applications that I made in and about the Grand Central Depot, New York, in 1871.

In addition to what is shown by this Exhibit No. 2, I applied an audible signal in the Hudson River R. R. waiting room of this depot, and an audible signal in the baggage room; also, an audible signal in the New York and New Haven waiting and baggage rooms; the New York and Harlem waiting and baggage rooms; the inward baggage room in the operator's room, at the north end of the depot; all in the Grand Central Depot.

This code of signals were all attached to and operated by one and the same battery; wires extending to the operator's room, and connecting with circuit-closers.

Each of these circuit-closers was a nickel-plated key on the operator's table, made for the purpose, and each key was lettered as follows:

One was lettered, "H. R. Waiting Room," by which was meant Hudson River Waiting Room; another was lettered "H. R. Baggage Room," by which was meant Hudson River Baggage
332 Room; another was marked "N. Y. & H. Waiting Room," meaning New York and Harlem Waiting Room; another was lettered "N. Y. & H. Baggage Room," by which was meant New York and Harlem Baggage Room; another was marked "N. Y. & N. H. Waiting Room," by which was meant New York and New Haven Waiting Room; another was marked "N. Y. & N. H. Baggage Room," by which was meant New York and New Haven Baggage Room. There was one marked "Inward Baggage Room," there was one marked "Switch Start."

In addition to the audible signals first named, there was a large signal connected with the key or circuit-closer, marked "Switch Start," placed at the north end of the Grand Central Depot, near the track, where all inward trains were drawn out by the switch engine, as soon as the passengers left the cars and the baggage was unloaded into the receiving baggage room.

These audible signals described were all connected to the different keys that I have described, and all connected to and operated by one battery.

In addition to these, there was another audible signal placed in the operator's room, connected to a circuit-closer in the inward baggage room, with a ground return.

This was also operated by the same battery as the others.

The operation of this code of signals, I will now describe: On the arrival of a train, as soon as the baggage was removed from the baggage car, the passengers having all left the train, the baggage master would operate his circuit-closer, which would strike a bell in the operator's room in the north end of the depot. The driver of the switch engine, having in the meantime hitched on the rear end of the train, would be notified by the large bell placed near him, being struck by the operator in the signal room, by depressing the key marked "Switch Start."

The engineer, thus notified, would immediately draw
333 out the train on to a side track, leaving the track clear to be occupied by an incoming train.

Five minutes before the time for an out-going Hudson river train to leave, the operator would momentarily close the circuit by depressing the key marked "H. R. Baggage Room," and thus strike a bell in that baggage room. This signal would notify the baggage master to close the doors of the baggage-room, and give him five minutes to get his baggage on board of the train.

Fifteen minutes before the time for a train to leave, the operator would twice momentarily close the circuit by depressing the key marked "H. R. Waiting Room." This would strike the bell twice in the passenger waiting room, which would notify the door-tender in the waiting room to open the door, allowing the passengers to go to the cars. Two minutes before it was time for the train to leave, the operator would momentarily close the circuit once on the same key. This was a signal to the door-tender to close the door and

allow no more passengers to pass out to that train, thus giving the passengers that had last passed out two minutes to get on board the train.

The same rule that governed the operator in operating the two last-described signals will describe the applications made and the rules carried out in regard to the signals to the N. Y. & Harlem waiting and baggage rooms and the N. Y. & N. H. waiting and bagbage rooms. Besides what I have mentioned, and in addition to what apparatus is represented on Exhibit No. 2, there were other applications outside of the depot, and also three inside of the depot. The signals outside of the depot were attached to three posts set outside of the depot, about 50 to 100 feet from the north end of the depot. These posts were placed in close proximity to the outward branch tracks of the New York & Harlem, the New York & New Haven, and the Hudson R. railroads, respectively. The other signals were placed on the north end, just inside of the depot, in
334 close proximity to the three tracks last named. All these signals were connected by means of wires to keys in the operator's room, and were all operated by the same battery by which the eight signals last described were operated.

Their operation was as follows: About ten minutes before it was time for a train to start, the engine-drivers of the different roads were required to back their engines to points on their respective tracks directly opposite the posts to which these signals were attached.

Two minutes before it was time for a train to start, it was the duty of the operator momentarily to close the circuits, the keys of which were marked respectively, "H. R. Back," "N. Y. & H. Back," "N. Y. & N. H. Back." This caused the bells on the posts to sound, and this was the signal for the engine-drivers to back down and hitch on to their trains.

The circuit-closers that were connected with the three bells, placed directly inside of the depot, in close proximity to the three tracks, were marked respectively, "N. Y. & N. H. Start," "N. Y. & H. Start," and "H. R. Start."

After the engine-drivers had attached their engines to the trains, they would be in close proximity to their respective signals, placed just inside of the depot. When it was time for them to start, they would be so notified by the operator, by depressing his key two or three times, which would cause the bell to strike as many times, which would be a signal to start.

Hearing adjourned to Friday, June 22, at 9.40 a. m.

335 NEW HAVEN, *June* 22, 1877.

Parties represented by counsel as yesterday.

Examination of THOS. S. HALL resumed:

I wish to make the following corrections in my testimony of yesterday, on the 114 and 115 pages of the defendants' printed testimony. Commencing on the 114 page in the eighth line from the bottom, in my testimony there, I stated, "the signals outside of the

depot were attached to three posts outside of the depot, about 50 to 100 feet from the north end of the depot. These posts were placed in close proximity to the outward branch tracks of the New York & Harlem and the New York & N. H. and the Hudson River railroads, respectively. The other signals were placed on the north end just inside of the depot in close proximity to the three tracks last named. All these signals were connected by means of wires to keys in the operator's room, and were all operated by the same battery, by which the eight signals last described were operated."

The correction I wish to make is, as follows: The three signals attached to three posts located from 50 to 100 feet from the north end of the depot, were operated by an independent battery, and connected with circuit-closers in three visual signals located in the large signal house, which were marked, respectively, on the discs, X, Y, and Z. These visual signals were operated by circuit-closing keys in the operator's room, which were also lettered X, Y, and Z to correspond with the signals.

Their operation was as follows: When the train dispatcher or operator wished an engine to be attached to a train he would close a circuit by the key, whose letter would call for the one required.

336 This would bring the signal into sight directly ahead of the engine-driver, and the bell would immediately commence to ring by his side or near him, and they would always be able to know by the letter on the disc of the signal displayed which engine was required. The discs of these signals were of different colors, one being blue, another orange, and the other green.

The three signals just inside the depot were operated by the same battery that all the other signals in the depot were operated by, as I stated in my testimony yesterday.

I now introduce a plan of the signals at the Grand Central Depot described yesterday, but it does not include the correction made this morning.

(Defendants put in evidence the diagram referred to, which is marked Exhibit 34, E. E. M., Ex'r, June 22, 1877.)

This exhibit is the complement of Exhibit No. 2, and both together represent the outlines of my entire application in the Grand Central Depot in 1871.

I heard the testimony of Alvah W. Hall, given in this case, explaining Exhibit No. 2, which is printed on pages 5 and 6 of the defendants' testimony, and I have carefully read the same since it has been printed and the same is entirely correct.

In connection with the written explanation on Exhibit 2, it correctly explains the application therein described.

I now introduce a photo-electrotype of Exhibit No. 15.

(Defendants place in evidence the photo-lithograph referred to, which is marked Exhibit No. 35, E. E. M., Ex'r, June 22, 1877.)

On account of the difficulty of photo-electrotyping the red-ink lettering on Exhibit No. 15, I had similar descriptive remarks to

those in red ink on that exhibit printed on small slips of
337 paper, which were temporarily pasted over the original lettering. These slips were removed before Exhibit No. 15 was laid in this case.

Exhibit No. 35 correctly represents an application of my automatic electric block-signal system, which I applied on the N. Y. & H. R. R. from Grand Central Depot, six miles north, in the year 1871, together with some changes made at or near Mott Haven junction in the winter of 1871–'2.

These changes were slight and consisted in changing the location of one or two signal houses or posts, and possibly the changing of one or two wires, to which an additional bell might have been added. I will describe what I mean by my block system of signals.

By the phrase "block system," as thus used, I mean the system of securing an absolute interval of space between successive trains on the same track, instead of relying on attempting to secure an interval of time. My system secures an interval of space between successive trains, which operates as a block to separate them, thus excluding or blocking the following train out from said space.

This application, shown by Exhibit No. 35, consisted of twenty visual signals placed at different points on the line of the two tracks. The first at 50th St., the second at 53rd St., the third at 56th St., and the fourth at 57th St., the fifth at 76th St., the sixth at 77th St., the seventh at 98th St., the eighth at 102d St., the ninth at 117th St., the tenth at 122d St., the eleventh at 125th St., the twelfth at 131st St., the thirteenth at 134th St., near Harlem river; the fourteenth beyond Harlem river, connected with the draw; the fifteenth and sixteenth near Mott Haven junction, the seventeenth and eighteenth on the branch road connecting the Hudson River R. R. with the Harlem R. R., the nineteenth and twentieth are between Mott Haven junction and Mott Haven depot. In connection with this series of visual signals placed on the line of the road, were not less than thirty-five track circuit-closers. In connection with these track circuit-closers
and visual signals, there were about twenty audible signals
338 attached. There were also, in connection with these visual signals and the track, not less than twenty double-circuit instruments. There were twenty signal houses, which contained these visual signals, audible signals, and double-circuit instruments.

There were wires also attached to telegraph poles, and also attached to the signal houses, and to the track circuit-closers. In these houses there were also batteries for operating the visual and audible signals in connection with the double-circuit instruments and the track circuit-closers.

I will now describe the operation of this code of signals: Commencing one mile from the Mott Haven junction, on the N. Y. Central R. R. and Hudson River R. R., was located a signal house, to which was attached a visual signal and double-circuit instrument, and in which was a battery; and at the track close to the house was a track circuit-closer. There were wires extending from this house to another track circuit-closer, connected with the track near the junction, at a point marked on Exhibit 15, "lever lowers mile block

signal west on N. Y. C. and H. R. R. R." There was also a bell connected with the double-circuit instrument of this signal, which bell was located in the telegraph office at the junction. The operation was as follows: At a point near signal house, written in red ink, "lever raises block signal and rings bell at telegraph office," was located a track circuit-closer. (I may here say that whenever the word *lever* is used in this Exhibit No. 15, it is used with the meaning of *track circuit-closer*.)

When the wheels of the train came in contact with the track lever, it would momentarily close a circuit, which would vitalize the raise magnet of the double-circuit instrument, thus attracting its armature by electro-magnetism; the remaining lever of said double-circuit instrument would take its place by means of a spring, and would continue the effect that was produced by momentarily vitalizing said magnet. In connection with this double-circuit in-
339 strument there were two circuit-closers, to one of which was attached two wires and a bell, located in the telegraph office, at junction, as already mentioned. To the other circuit-closer of the double-circuit instrument there were attached two wires which connected with the visual signal and a battery.

There was also a battery, to which were connected the raise and reverse magnets of the double-circuit instrument, the magnet of the bell, located in the telegraph office at junction, the track circuit-closer near the junction, and the track circuit-closer one mile from the junction, near the signal-house.

As soon as the last-named track circuit-closer was operated upon by the wheels of a train, said circuit-closer would be locked in position, the bell would commence to ring in the telegraph office, and also the visual signal would be displayed by means of the other double-circuit instrument, circuit-closer; and the visual signal thus displayed would continue, and the audible signal would keep sounding until the train had reached the junction and operated upon the track circuit-closer, which is marked in red ink "lever lowers mile block signal west on N. Y. C. and H. R. R. R." This circuit, being momentarily closed, vitalizes reverse magnet of double-circuit instrument, which attracts the armature of retaining lever by electro-magnetism, and instantly opens the two circuit-closers attached to the double-circuit instrument, which disconnects the battery from the visual signal and also the battery connected with the two track circuit-closers and the raise and reverse magnet of the double-circuit instruments, and the magnet of the bell, when the bell stops sounding.

In this case the circuit-closer attached to the double-circuit instrument and the battery connected with the visual signal are suitable and proper mechanical means for operating the same. When a train proceeding beyond this first block signal, approaching the junction, reaches a point marked on the exhibit in red ink "lever
340 rings draw-bridge bell," a bell is immediately rung at the draw-bridge by means of a double-circuit instrument and battery for that purpose. Said bell continues to ring until the train reaches the point on the track marked "lever A stops bell-ringing

at draw-bridge," when a circuit is momentarily closed by its wheels, the reverse magnet of the double-circuit instrument vitalized and retaining-lever withdrawn by electro-magnetism attracting its armature.

In this application we have two track circuit-closers placed at different points on the track, an audible signal at another point, to which is connected a magnet and a double-circuit instrument at another point, with its two magnets; all of which are connected to and operated by one and the same battery.

I will now describe an application which is marked No. 2. This is a different application.

At a point marked in red ink "lever sets No. 3 signal on N. Y. C. & H. R. R. R. near junction," is a track circuit-closer, and also a signal-house marked No. 2. At a point on the N. Y. & H. R. R. above the junction at a place marked in red ink "No. 3 signal is raised by lever at No. 2, or from telegraph office, also by switch at junction" there is also located a signal-house, marked No. 3.

Further up the track, at a place marked in red ink "lever raises signals Nos. 2 and 1, also rings bell in telegraph office from No. 2 signal," there is also located a track circuit-closer. In the signal-house No. 2, and connected therewith, there is a visual signal and double-circuit instrument, and also two batteries. On the track below the junction approaching New York, at a place marked in red ink "lever lowers Nos. 1 and 2, lever lowers No. 3 signal," are also two track circuit-closers.

In signal-house No. 3, on N. Y. & H. R. R., there is attached a visual signal, a double-circuit instrument, and two batteries.

341 A train approaching the junction of the N. Y. C. R. R. & H. R. R. R., its wheels, coming in contact with lever, near house marked No. 2, would cause a signal of danger to be displayed on house No. 3, on inward track of N. Y. & H. R. R.

This same signal was automatically operated by the movement of the switch; which, by its movement, caused a circuit to be closed when at a position of danger.

This signal No. 3 was also reversed by the train, by momentarily closing a circuit on the track circuit-closer, at a point marked in red ink "lever lowers No. 3 signal."

There were also two hand circuit-closers connected with signal No. 3, which were placed in the telegraph office at junction.

This No. 3 signal was raised and reversed, by momentarily closing the circuit of its double-circuit instrument, by two track circuit-closers and two hand circuit-closers. One switch circuit-closer was also directly connected with the battery and magnet of signal No. 3, independent of the double-circuit instrument.

Two of the first-named circuit-closers, one of each kind, were connected with the raise magnet of the double-circuit instrument, and the other two, being one of each kind, to the reverse magnet of the double-circuit instrument, and also the bell in the telegraph office, and the danger signal, by means of a circuit-closer on the double-circuit instrument, and a battery, which were proper and suitable mechanism for operating the same.

The other applications shown on this exhibit, or the most of them, are operated by the same means, and in a very similar manner, as these which I have described.

The signal at a point on the inward track marked 98th st. caused a bell to ring when set at danger, at the look-out of train dispatcher's office at Grand Central Depot, in the same manner as these which I have described at or near the junction.

The circuit-closers, which were attached to the draw-bridge signal to operate it, were attached to a mechanical drop-signal, which
342 was operated by its gravity, whenever the key which secured the draw-bridge was withdrawn. This signal was a heavy plank, and extended over the track on which the trains approached the draw, in such a manner, that when it was released as above stated it would fall to a position directly in front of the smoke-stack of a locomotive so as to strike it, if the train proceeded. This was to prevent accidents, by giving a signal to the engineer, which he could not help heeding, in case he did not see the visual signal. The attachment of this signal to the draw was automatic.

On the 27th day of May, 1872, I made a contract with the Eastern R. R. of Massachusetts, by which I licensed them to use my automatic code of signals, and received therefor the sum of $10,000.

I proceeded in the summer of 1872 and equipped the road with my signals from Boston to Salem and beyond, a distance of not less than seventeen miles in all. The general character of this application was substantially the same as that made on the New York & Harlem R. R., with the exception of the attachment of our safety signal in connection with the one-mile block danger signal.

(Defendants place in evidence diagram, lettered Sketch No. 1, etc., which is marked No. 36, E. E. M., Ex'r, June 22d, 1877.)

This diagram, Exhibit No. 36, represents five one-mile sections of our danger and safety signals and track circuit-closers, by the perspective drawing shown on the upper part of this exhibit.

It also shows a plan of wires and batteries, with a skeleton view of double-circuit instruments and magnets, of danger and safety signals, as arranged and applied to this series of *intervals of space*, or *block* signals. There were also many audible signals connected with this series in the application between Boston and Salem.

Soon after this application was made, about the time it was completed in 1872, I published rules for governing engine drivers
343 in running their trains by this code of signals.

(Defendant's place in evidence copy of rules referred to, which is marked Exhibit No. 37, E. E. M., Ex'r, June 22d, 1877.)

The above exhibit comprehends the rules mentioned, which included a wood-cut and description of my apparatus.

This code of signals was put in successful practical operation that season. While constructing this line, for the sake of economy in construction and maintenance, I became convinced that it was essential that I should make further modifications and improvements in my signal system.

I gave the subject much thought and study, and during that year conceived a plan that convinced me perfectly that I had made the improvement desired.

This improvement consisted in modifying and combining two of my patented improvements; namely, my double-circuit instrument, No. 97505, Exhibit No. 22, and the reissue No. 4493, Exhibit No. 30, directly with my visual signal, patent No. 103,875, Exhibit F; which improvement would enable me to operate a larger number of signals, placed on both tracks of a railroad, by means of one battery. I tried my first experiment in the latter part of that year, by first connecting two double-circuit instruments, with two line wires, these instruments being placed at some distance from each other, said wires being attached to a battery, and branch wires connecting thereto with the raise, and also with the reverse magnets of my double-circuit instruments.

I found this experiment entirely successful. It was made in our shop in New Haven, cor. Whitney Av. and Howard St. Charles H. Mansur, employed by me, was present and saw me make the experiment. I told him what my object was, and gave him
344 general explanations of what I could accomplish by it. I immediately telegraphed or wrote to my son, A. W. Hall, who was then at Salem, Mass., to come to Meriden.

I will here state that he was engaged in assisting at the time in putting up the poles and telegraph wires and signal houses, and putting in the track circuit-closers between Salem and Ipswich. He immediately came to Meriden, as I requested, and I gave him a rough sketch, and directed him to run two insulated wires the whole length of a room that I had fitted up in the third story of our building, for the purpose of experimenting in. I told him to have one of the carpenters, who was then at work in the building, make shelves and attach them to the side of the building, of suitable size to hold my double-circuit instruments, and to place the same about eight or ten feet apart from each other. Upon these shelves five double-circuit instruments were placed. There were also two other double-circuit instruments placed on shelves on the walls of the opposite side of the room. The room was about eleven feet wide by forty-seven feet long. I told him to place a battery in an adjoining room, which was fitted up for a draftsman's room. I gave him instructions and directions, in addition to the sketch which I had given him, and told him what the object of the experiment was, what I expected to accomplish, and what I had accomplished by my previous experiment at New Haven. He went to work, and either the second or third day he reported to me, that he had put up the wires, and made the connections in every respect as I had directed him, and that the device would not work, and that he knew it would not, from the beginning. I told him that I thought I could help him out of his trouble, and would look the thing over. I went into the room with him, first saw that the two main wires were properly connected with the battery, also that the branch wires were properly connected with the raise magnet of the double-circuit instruments, but that he had omitted to run the branch wires connected

345 with the reverse magnet of the double-circuit instruments. He run those wires and connected them, as I directed, and we were not long in finding out that the device worked to perfection.

(The defendants place in evidence a model of a track circuit-closer, which is marked Exhibit No. 38, E. E. M., Ex'r, June 22, 1877.)

Exhibit No. 38 is a model of the track circuit-closer, about one-sixth size, that we used at the time of this experiment, in December, 1872.

On the day of the successful experiment just mentioned, I attached two of these model track circuit-closers like Exhibit 38 to the branch wires of the raise and reverse magnets, respectively, of one of said double-circuit instruments [all of which were precisely like Exhibit No. 3]. I then called at least three men that were at work for me, making not less than five, including myself and son. I had three of them take the branch wires that were designed to be connected with the track circuit-closing instruments, and one besides myself to operate the model track circuit-closing instruments like Exhibit No. 38, and we all closed the circuits at the different points momentarily, as near the same time as possible, and found the experiment to work to perfection. I immediately telegraphed Geo. H. Snow, who was engaged in our work between Salem and Ipswich, to come to Meriden. I sent the dispatch in the afternoon, or evening, and he arrived in Meriden the next day at about one o'clock p. m.

He came to my house and stated that he was afraid that I was sick, or that something serious was the matter; that he should have come from Boston on the night train the evening before, but did not receive my dispatch in season to do so. I told him I wished to stop all the work between Salem and Ipswich, as I had a plan whereby I could work all the signals on both tracks of the railroad,
346 visible and audible, between Salem and Boston, by the means of one battery.

Hearing adjourned to Tuesday, July 3, 1877, at 9.40 a. m.

NEW HAVEN, *July* 3, 1877.

Parties present by counsel as heretofore.

Examination of THOMAS A. HALL continued.

I wish to state that before telegraphing to Mr. Snow, and before he came to Meriden, I had my son make a correct drawing or sketch of this application, represented by Exhibits Nos. 5 & 6. I went to Boston with my son after the sketch was made, taking the sketch with us, and showed the same to C. F. Hatch, manager of the Eastern R. R., and fully explained them to him, and advised him to have the work discontinued, in putting up the signals between Salem and Ipswich, that we were at work upon.

Mr. Hatch told me that he saw one objection to my improvement; that was that, by the improvement, a long series of signals would be directly connected with each other, and in case of an accident to the line of battery wires, the whole section, which was

worked by one battery, would be interrupted; whereas, by the former plan, each section was independent and by itself. I stated to him that I thought that objection could be overcome, and told him that, as soon as I could adapt my instruments to the new plan, or one-battery plan, I would apply it between Salem and Lynn at our own expense, and after he saw it in practical operation, if he did not give the improvement his approval, that I would change it back to the previous or first plan at our own expense.

He assented to my proposition, and soon after I returned to Meriden.

347 This must have been in the early part of January, 1873, that we returned from Boston. I had other business in Boston, and may have spent several days there. On my return to Meriden I at once telegraphed to Mr. Snow. My conversation with Mr. Snow took place in my dining-room, in my house, at Meriden.

The conversation referred to is the conversation that I testified to prior to the last adjournment. When I stated to him my plans for working all the signals between Salem and Boston, by means of one battery, he said, "It can't be done."

I told him that, after he got through his dinner, I would show him the thing in practical operation, practically illustrated. I took him into the third story of the new shops of the Signal Company, into our "model-room," and showed him the device as represented by Exhibits Nos. 5 and 6. I exhibited the device to him, and explained every point. After we got through I asked him what he then thought about it; he replied, "I think it *is* done." He went to New Haven that afternoon. I told him I would be at the shop in New Haven early next morning. Before he left, however, I told him I wished him to go right to work in the shop at New Haven, with Mr. Mansur, and assist in making such changes and modifications in our electrical instruments as would enable us to operate our system upon the one-battery plan. We commenced the next morning, in our shop at New Haven, to make such modifications.

Mr. Mansur and myself had already applied the double-circuit principle directly to the danger and safety signals.

There were some modifications, however, that Mr. Snow assisted in making. We constructed a wooden track instrument, with metallic connections and divided anvils, to which we attached the danger and safety signals, Exhibits Nos. 16 and 17.

348 Mr. Snow stated about this time that he had to go back to Salem for his trunk, and did so. On his return he worked in the shop in New Haven upon these improvements until we removed to our new shops in Meriden, which was in the early part of March, 1873.

In working our system on the Eastern R. R. we had found our track circuit-closers, precisely like Exhibit No. 38, defective.

The levers would frequently break, and the spiral springs connected with the spindle would also break and wear out, and that would leave the circuit closed and the spindle remaining between the divided anvils, the spring failing to drive it back. In cases where the long lever, operated on by the wheels, broke, the danger

signal would fail to operate, and trains would be stopped by the safety signals when they ought not to be.

We perfected the first improved atmospheric or air cushion circuit-closer, and put the same in practical operation, in connection with the reverse magnet of the double-circuit instrument of one of our crossing signals, on the down track of the Hartford & New Haven R. R., at Meriden, Conn., in April, 1873.

The first air-cushion track circuit-closer was made by hand, with such machinery as we then had in our shop.

As soon as its practical utility had been perfectly established I commenced to make a complete set of tools especially to manufacture these atmospheric track circuit-closers. This occupied quite a period of time. I first exhibited the apparatus represented by Exhibits Nos. 5 and 6, as set up in my shop at Meriden, soon after it was put up, to Charles Parker, of Meriden, who afterwards became president of the defendant company; Dr. Wilson, of Meriden, my family physician, who was very much interested in my inventions; Perkins & Lines, of Meriden, builders, and many other persons in Meriden. We connected a second track instrument, by permission of Mr. Reed, superintendent of the Hartford & N. H. R. R., with the down track of that railroad, and extended a line of telegraph
349 poles to our shop, upon which we put wires, connecting the wires with the track-closing instrument on the track with the battery and other apparatus in our shop. We disconnected one of the double-circuit instruments, which was on the wall next to the battery, as represented by Exhibit No. 5, and placed near it the danger signal, Exhibit No. 17. This danger signal was placed on a frame made for the purpose. We extended the branch wires, which had been connected with the raise and reverse magnets of the double-circuit instrument to the raise and reverse magnets of this signal, by splicing on wires of sufficient length. We also connected with the danger signal safety signal, Exhibit No. 16, which was also arranged on a frame, a short distance from the danger signal, by means of a circuit-closer attached to the danger signal, to which circuit-closer were connected branch wires with the main battery wires and the raise magnet of the safety signal, precisely the same as those connected with the raise magnet of the danger signal. There was also an audible signal, connected with the safety signal and the same battery, together with a circuit-closer attached to the safety signal

We also connected the reverse magnets of the danger and safety signals with a branch wire connected with the battery. This series of signals being connected with a track circuit-closer connected with the railroad track; they were operated by all down trains, which would momentarily close the track circuit-closer and vitalize the raise magnet of the danger signal, when the long arm of the disc of said signal would momentarily close the circuit-closer attached to it, which would vitalize the magnet of the safety signal, causing it to raise out of sight. By the motion of the safety signal a circuit-closer attached to the disc lever would momentarily close a circuit three or four times by its vibrations, which would again bring the battery

into use, vitalizing the magnet of the audible signal, causing it to sound as many times as the circuit was closed.

350 To the reverse magnets of the danger and safety signals were also attached branch wires, extending to the main battery wires, which were attached to a model track circuit-closer, like Exhibit No. 38. I have described the operation of the signals by means of the trains. By means of this track circuit-closer, like Exhibit No. 38, I reversed the signals by hand, by depressing the lever. I also had raise and reverse hand circuit-closing instruments connected with these signals, with which, by momentarily closing the circuit, I could raise and reverse the visual signals and operate the audible signals.

I invited E. M. Reed, sup't of the Hartford and New Haven R. R., to examine these improvements. He notified me of the train he would come on; I met him at the depot and took him to the shop to examine the apparatus there, and also took him out on the track of the railroad to examine my application there, that I have just been describing. I also showed these improvements to a great many persons that summer.

We continued during that season to manufacture tools for the purpose of manufacturing our improved visual signals, and other devices pertaining to the subject.

On the 12th of November, 1873, I shipped to Boston all the improved instruments requisite to fully illustrate its practical utility.

On the 13th or 14th I put the same in a large hall in the new Boston and Lowell depot, and saw the wires—nearly all of them—properly connected.

I returned to Meriden on the afternoon and evening of the 14th; was very ill at the time, and was unable to give my business my personal attention, any further than what I could by verbal communications with my son, Alvah W. Hall, who was a portion of the time with me, and by written directions to other persons employed by me, until the following spring or summer. I think it was May or June, 1874, before I was again able to visit Boston.

351 On the 10th of November, 1873, I issued circulars to the railroad men of Boston, that I should exhibit my improvements in signals at an early date.

On the 15th of November, 1873, after my return home, I issued the circular Exhibit No. 12, and also prepared tickets like Exhibit No. 13 for an exhibition on November 20th, but my physician told me that it was impossible for me to be present then, and I gave up the exhibition for that time. On the 25th of November, 1873, I received a letter from Mr. C. F. Hatch in answer to one I had written him November 22, in which he states he had received my favor of the 22d, and had looked over my improved apparatus with Mr. Snow, etc.

(Defendants' counsel place in evidence letter referred to, which is marked Exhibit 39, E. E. M., Ex'r, July 3, 1877.)

I then had my men commence at once to equip the road between

Salem and Lynn with my improvements I heretofore described, as I had agreed with Mr. Hatch the spring before.

After I commenced to go to Boston in May or June, 1874, I visited my work on the Eastern R. R. and attended to my business in Boston and on railroads near there, as often as every other week, all the summer, with the possible exception of two vacation trips of three weeks each, until October, 1875.

(Defendants lay in evidence copy of patent No. 165,570, dated July 13th, 1875, issued to T. S. Hall and George H. Snow, which is marked Exhibit No. 40, E. E. M., Ex'r, July 3, 1877.)

I filed my application for this patent June 23d, 1875.

Exhibit No. 8 is a correct description of the application on
352 the Eastern R. R., as I saw it, in May, 1874, of my improved apparatus, and the description at the foot of the diagram is correct; it worked perfectly satisfactorily.

(Defendants place in evidence diagram, which is marked Exhibit No. 41, E. E. M., Ex'r, July 3, 1877.)

This diagram correctly represents my first practical experiment with my double-circuit instrument, as applied to signals at highway crossings, which I have described on page 98 of defendant's printed testimony. I have had this diagram made since the last adjournment. The description of the lettering, given at the bottom of the diagram, is correct.

The double-circuit instrument, represented in the diagram, was the same as Exhibit No. 3, except the armature lever of the upper or reverse magnet was then made perhaps an eighth of an inch shorter than now. The two iron stands in the center of the instrument, for the armature and circuit-closing levers, are not represented in the diagram; but they were, in fact, part of the instrument, as now. The same is true in respect to the iron stand for the armature lever of the raise magnet. I will also state that for convenience the two posts, one of which is marked New Hope, with their connecting wires extending to the freight depot, are placed at the top of the diagram, near the track for trains going to New Haven, but they were, in fact, placed on the other side of the track, adjacent to that for trains going to New York.

My improved system of apparatus, as applied on the Eastern R. R., in the early part of 1874, covered, at least, seventeen miles of double track road, on that road.

In the fall of 1874, I sold the Boston, Lowell and Nashua R. R. the right to use my improved system of automatic electric railway signals, for which they paid me the sum of $5,000 for right to use
the same. We equipped that winter and the following
353 summer eleven miles of double track road of that road lead-out of Boston.

In the winter of 1874–5 I also sold the right to use my improved system of signals to the Boston and Albany R. R. Co., for which they paid me $10,000.

During the spring, summer, and autumn of 1875 I equipped

their double-track road from Boston to South Framingham, a distance of 22 miles, with my system.

The same year, 1875, I sold the right to the Old Colony road to use my improved system, for which they paid me the sum of $5,000 for a license to use the same.

That year we equipped four miles of their road between Boston and Harrison Square, and also two or three miles more at Quincy. Since that time they have extended the application not less than eleven miles from Boston.

All these applications are in successful operation at this time.

I should say at least two or three months prior to the application therefor, which was Dec. 31, 1873, I commenced getting up the application, specifications, and drawing for patent No. 150,030, Exhibit No. 11.

The plan of wires shown in this patent, with the branch connections to the several instruments, safety and danger visual signals, and audible signals, track circuit-closers arranged on the line of the road, two hand circuit-closing instruments, and their connections, in combination with two line wires and a battery—all of this I invented in the year 1872, and applied the same substantially, in the shops of the Hall Signal Railway Company, in the latter part of that year, and put it in operation, substantially as shown by Exhibits Nos. 5 and 6.

It has been my custom, invariably, as I have heretofore stated, to put my inventions into practical operation, so far as becoming convinced of their practical utility, before making applications for my patents. That was my manner of procedure in the case of
354 this patent. I did not apply for this patent for upwards of a year after I had made the invention.

Some time during the summer of 1873, or in the fall, after I had perfected my mechanism fully, to put this improved system in operation, I invited my patent agent, or expert, Mr. Hauff, of Van Santvoord & Hauff, to come to Meriden for the purpose of making a thorough examination of the improvement, with the view of making application for a patent for the one-battery system, which I had invented, in combination with visual and audible signals, track and hand circuit-closers, switch machines and application to drawbridges, which constituted the system.

He came to Meriden as requested, and spent sufficient time to obtain such knowledge as would enable him to make an application that would secure my just claims for a patent.

Owing to the amount of work required in making the drawings, together with my illness, the application was not filed till the 31st day of December, 1873. The drawings in this patent were made from the apparatus I had in Meriden, as partly represented by Exhibits Nos. 5 and 6, with the exception of that part referring to drawbridge, etc.

The reason why I did not apply for patent No. 165,570, until June 15th, 1875, was the same reason that I have previously given in regard to my other improvements, which was to give a sufficient length of time for testing its practical utility, that I might become

convinced that I should not require to make any further improvements before making application for a patent. It was about a year and four months before making application for this patent that I made the invention described therein.

I am quite familiar with patent No. 140,536, issued to F. L. Pope July 1st, 1873. I wish to state from an experience of upwards of ten years, during which time I have exclusively devoted my whole and entire time to the science of utilizing electricity and
355 electro-magnetism, inventing electric machinery and applying the same to the art of railway signalling, automatically and otherwise, in which I have expended not far from $200,000, that I call myself a good judge—in fact, an expert upon the subject; and after carefully and critically examining this patent, I fail to discover anything which, of itself, would constitute a valid patent; and in my opinion a man skilled in the art of utilizing and applying electricity and electro-magnetism to railway signalling could not find in this patent, illustrated and described, suitable means to put one or more signals, visual and audible, into practical operation.

In all my inventions I never have taken an idea from any person's inventions, either foreign or domestic, with the exception of those ideas which I have taken from the electric telegraph, and the mechanism connected therewith, and the burglar alarm telegraph, which I had in use in my house in Stamford in the years 1864–5, and '6, which principle I applied to my first switch application made at Stamford late in the fall of 1866.

I never saw Mr. Pope's patent, No. 140,536, until after we had been threatened with a suit by one Mr. Edgecomb, of Hartford, I think, in the year 1875. I positively state and assert that I never saw or heard of the plans represented in Mr. Pope's patent until long after I had made my inventions and put them into practical operation, as stated, and I never derived any aid or used any ideas from the same.

I wish to state that in my many inventions I have received much valuable mechanical assistance from Mr. Geo. H. Snow, and other mechanics employed by me for that purpose.

Cross-examined by Mr. PERKINS:

Cross-int. 1. State the difference between the invention described in letters patent 97505, issued to you, and that described in the reissue thereof, No. 4493.

356 Ans. The specification of the patent fully describes my invention, and I do not know and I cannot see that the reissue any more fully described it. I changed my patent attorneys from Munn & Co., who took out the patent 97505 for me. In applying for this patent, they detached the circuit-closers *b b* from the model which I had made first. After employing Van Santvoord & Hauff, I gave them all my patents that I had taken out up to that time, and requested them to make a critical examination of the same, and stated to them if they found it necessary in any of them I would apply for a reissue. Upon their recommendation this reissue was

applied for and granted. I consider now, as I always have, that they were both substantially the same for accomplishing the object designed.

Cross-int. 2. Do you mean that you can see no difference whatever between the two?

Ans. I mean that they are substantially the same. The original model which I had made and took to Munn & Co. to forward to Washington with the application for a patent on the same, was in every particular like the drawing in 97505. Munn & Co.'s agent detached the two circuit-closers marked *b b*, connected with the rod marked *a*, from the long armature lever of the raise magnet of the model, and did not send them to the Patent Office. I told him I was not pleased with his idea in doing this, and after I employed Van Santvoord & Hauff, when we applied for the reissue of 97505, we sent a double-circuit instrument, precisely like Exhibit 3, to the Patent Office, with the application for a reissue. This model contained the circuit-closers, which were left off the model, which was sent with the application for the original patent.

Cross-int. 3. Do you mean, then, that with the exception of the addition of the circuit-closers *b b*, there is no difference between the patent and reissue?

Ans. I will look at them and answer at the next hearing.

357 Cross-int. 4. What was the object obtained by the invention of this double-circuit instrument, over what was known before?

Ans. The object of this invention, in combination with track circuit-closing keys, which I had invented at this time, together with visual and audible signals which I had already invented, was to enable me to operate one or more visual or audible signals placed on the line of a railroad, by the movement of a train, whereby its wheels would momentarily close a circuit of a track circuit-closing instrument, thereby vitalizing the raise magnet of the double-circuit instrument, and thus put a visual or audible signal or both in operation, and the retaining armature lever of the reverse magnet of the double-circuit instrument locking in place the armature lever of the raise magnet of the double-circuit instrument (by this mechanical means, that is, the retaining lever), the effect produced by momentarily closing the track circuit-closer, by the wheels of a train, would momentarily vitalize the raise magnet of the double-circuit instrument, and attract its armature, and move its armature lever connected therewith; and the effect produced would be continued, notwithstanding the cause which produced the effect (the momentarily closing of the track circuit-closer) was taken off or removed.

The battery, which was used in combination with the track circuit-closer and the raise magnet of the double-circuit instrument, being used to operate an audible signal and secondary battery, connected with a visual signal, through a circuit-closer connected with a double-circuit instrument, marked *b b*, on patent 97505, would operate the visual signal.

In connection with the first battery named, to which was attached the track circuit-closer described, was also connected, at a remote

distance, another track circuit-closer and a reverse magnet of the double-circuit instrument, in such a manner that, when a train
358 had operated upon the first track circuit-closer named, the effect thus produced, as described, would continue until the train had reached the second track circuit-closer named, at a remote distance from the first, when its wheels would come in contact with the said circuit-closer, momentarily closing it, and vitalizing the reverse magnet of the double-circuit instrument, attracting its armature by electro-magnetism, and withdrawing the lever connected therewith; thereby opening the circuits, which had been closed, and held closed, by said armature lever, and by the means described; which would cause the visual signal of danger to fall out of sight and the audible signal to stop sounding, thus leaving the whole apparatus in its normal or first condition.

Hearing adjourned to July 5th, 1877, 10 a. m.

NEW HAVEN, *July* 5, 1877.

Parties represented by counsel as before.

Cross-examination of T. S. HALL resumed.

Answer to cross-int. 4 continued as follows:

In other words, continuing this description, the object to be obtained by patent 97505 was to provide suitable means for developing a principle which I had discovered in the winter of 1868–'9.

This principle was the utilizing of electricity and electro-magnetism in a way and manner that would enable me by momentarily bringing a battery into use at one point by the movement of a train of cars, to put into operation visual and audible signals, and to have them continue in operation until the train had reached another point at some remote distance, when by its movement it would momentarily bring the same battery into use by closing a circuit, as in the first case, and thus cause the signals to be reversed or taken off.

359 In reference to cross-int. 3, I would say that I have carefully examined and compared patent 97505 with reissue 4493, and while I find some slight variations in the specification, I consider them substantially one and the same thing.

Cross-int. 5. Is this double-circuit instrument anything more than a device for continuing in existence a circuit momentarily formed by a track circuit-closer, and which circuit, without the interposition of the double-circuit instrument, would only be momentary, and destroying that continuous circuit when desired?

Ans. This double-circuit instrument, as illustrated by Exhibit No. 3, in its present form of construction, by its connection with a battery and a track circuit-closing instrument, by momentarily closing the circuit through the track instrument, will not only vitalize its raise magnet and attract its armature, and put in operation the armature lever of the reverse magnet, but will also close a secondary circuit in connection with rod *a*, and one of the circuit-closers *b b*, in patent 97505, said circuit-closer being connected with the same battery as the raise magnet and the track circuit-closer, and also

with a magnet of an audible signal; said audible signal being constructed according to the patent 105,447, and patented by me July 9th, 1870.

The construction of this audible signal was such as, by the means of two springs, and their connection by wires, being connected with the bell hammer B and rod C and armature E, that when the circuit was closed on one of the double circuit-closers *b b*, this audible signal magnet would be momentarily vitalized, and then unvitalized, in altenation; which would attract its armature E, when vitalized, and cause it to strike a gong, thus giving an alarm. There was also a visual signal connected with the other of the two circuit-closers marked *b b* on patent 97,505, and which was also connected by suitable wires through a secondary battery to the magnet of said
360 visual signal. This visual signal would continue displayed as long as the effect continued, caused by momentarily closing the circuit on track circuit-closing instrument, as described.

In connection with the magnet E of patent 97505, there was a secondary track circuit-closer, which was connected with the same battery as the raise magnet, marked B B, and the first-named track circuit-closer.

This secondary track circuit-closer is called the reverse track circuit-closer.

By a train's momentarily closing this secondary track circuit-closer, it would vitalize magnet E, vitalizing its armature D, withdrawing its lever F F, allowing the armature of lever C of magnet B to fall, thus reversing or taking off the effect caused by momentarily closing the circuit, through the first-named track circuit-closer, as described.

It will thus be seen that the double-circuit instrument does not continue in existence the circuit which was momentarily formed by track circuit-closer and raise magnet marked B, but continues the effect thus produced.

It will also be seen by my answer that the power of the same battery, which produced this effect, is transmitted to an audible signal, as described; and further, that the visual signal is also put in operation, all of which continue, until the power of the battery, which produced this effect, is transmitted to and through the secondary or reverse track circuit-closer, connected with the reverse magnet E, which takes off the effect which was first produced, by attracting its armature D, connected with retaining lever F F. In fact, this double-circuit instrument is, virtually and substantially, an electric signal, provided with a lever F F, which will keep displayed, and in operation, audible and visual signals, after the electric circuit through the magnet, which sets the signals in operation, is broken as described.

Cross-int. 6. Will you examine the two claims contained in
361 reissue 4493, and state whether or not they correctly describe the invention shown in the double-circuit instrument, and secured by that reissue?

Ans. To correctly carry out and develop the principles of my inventions, which I discovered in the winter of 1868–9, and to reduce

these principles to practice in such a way as would produce useful results, it became necessary for me, in addition to an audible signal, which I had invented, but had not at that time patented, and visual signals, which I was at that time experimenting upon, and track circuit-closing instruments, which I was experimenting upon at that time to perfect these various mechanical devices, together with my double-circuit instrument, in order that I might be enabled to put my new principle of utilizing electricity and electro-magnetism in the the art of railway signalling into practical use.

These claims, 1 and 2, in the reissue of 97505, which is 4493—these two claims, together with the specifications which are designed to embrace and set forth the visual aud audible signals and track circuit-closers, as described, do substantially cover the invention shown by that reissue.

Cross-int. 7. In what part of the specification of said reissue is a track circuit-closing instrument described?

Ans. I allude to it in that clause where it says: "Or to produce any other effect, whenever the circuit through the first electro-magnet is closed in such a manner that by the locking lever or stop the armature lever of the first electro-magnet is retained in position after the circuit through said electro-magnet has been opened, and the effect produced by said armature lever is continued until the same is released by the locking lever or stop. With the locking lever is combined a reversing magnet, so that by closing the circuit through this reversing magnet the locking lever is withdrawn from the armature lever of the first magnet, and as said armature lever is permitted to fall back the effect produced by its action is
362 reversed—that is to say, if by its action a signal has been displayed the signal is taken off. When said armature lever falls back, or if by its action a circuit through another magnet has been closed, the circuit is opened when said armature lever falls back."

I also refer to it in the following sentence:

"By these means I am enabled to put on a signal by closing the circuit through the helix B momentarily; then keep the signal on by the action of the stop F on the lever C, and finally take off the signal by momentarily closing the circuit through the helix D."

Cross-int. 8. In what part of this last quotation from the specification is there a track circuit-closing instrument described?

Ans. I allude to the track circuit-closing instrument where I quote from the specification "by these means I am enabled to put on a signal by closing the circuit through the helix B momentarily, and then keep the signal on by the action of the stop F on the lever C, and finally take off the signal by momentarily closing the circuit through the helix D."

Cross-int. 9. Do you mean to say that, in your opinion, that quotation contains a description of a track circuit-closing instrument?

Ans. I mean to say that in that quotation there is an allusion directly to my track circuit-closing instrument. I will also say that in my patent, 103,174, I set forth and describe the object for which said patent was designed, and the functions which said invention

was designed to perform, and that I did not design in my patent 97505, nor in its reissue, 4493, to fully describe my track circuit-closing instrument, but only to allude to the same, that the principles embodied in my discovery in this series of signals might be correctly understood.

Cross-int. 10. In what part of the specification of said reissue are visual and audible signals embraced and set forth, as referred to by you in your answer to cross-int. 6?

363 Ans. In that portion of the specification commencing: "The armature lever *c* may connect by a rod *a*, or by any other suitable means, with a signal apparatus in such a manner that whenever the armature *a* is attracted by its magnet, and consequently the armature lever *c* swings back in the direction of the arrow marked near it in Fig. 1, the signal is displayed or set in motion, and whenever the armature lever is allowed to fall back to its original position, the signal is taken off or stopped."

Cross-int. 11. On page 102, defendants' printed testimony, you say: "In fact, two signals, or their equivalent, a double-circuit instrument, and an audible signal;" how is a double-circuit instrument an equivalent for a signal?

Ans. At the present time I construct my visual signals, combining my patent 97505, reissue 4493, with my patent 103,875, which are my double-circuit instrument and my visual signal; and these same principles were used in the description given of the application in my printed testimony, page 102, together with an audible signal connected therewith, as described. Perhaps I should say the combination is illustrated by Exhibits Nos. 16 and 17.

Cross-int. 12. At the time of the application at Stamford, shown in Exhibit 1 A, had you combined these two patents in the manner referred to in your last answer?

Ans. No, sir; I had not, as I do at the present.

Cross-int. 13. At that time, then, was the double-circuit instrument alone, as used in that application, an equivalent for a signal?

Ans. It performed substantially the same function in connection with my signals as it does now in the present combination. The present combination simplifies and increases the utility of the instruments.

Cross-int. 14. Is this application at Stamford now in operation?

Ans. To the best of my knowledge, it is not.

364 Cross-int. 15. Are any of the applications you have referred to, as placed by you on the New York and New Haven and Hartford, New York and Harlem, and Hudson River R. R., now in operation?

Ans. To the best of my knowledge and belief, the application at Cedar Hill, on the Hartford and New Haven R. R., is now in operation, and has been, since applied; also the application at Bridgeport draw-bridge at South Norwalk, on the New York and New Haven R. R.; also at the Harlem draw-bridge on the New York and Harlem R. R., together with the code of signals that I put in operation in the Grand Central Depot. As to the block signals, now in use

on the Harlem R. R., between Grand Central Depot to and connecting with Mott Haven junction, called the Rousseau Signals, they are substantially my inventions, with such alterations and changes, as to make the code, in my opinion, ineffectual and worthless; and are only allowed to be continued from the fact that the Harlem R. R. Co. holds a perpetual license to use my inventions.

Cross-int. 16. In the application at Cedar Hill, described on pages 104 and 105, defendants' printed testimony in this case, how many signals were used?

Ans. There was one double-circuit instrument, and one visual signal in and attached to the signal house, and an audible signal, which was placed about 1,000 feet from the visual signal.

Cross-int. 17. How many batteries were used to actuate the audible and visual signals?

Ans. There was one battery, to which was attached and connected the double-circuit instrument, the audible signal, and the raise and reverse track circuit-closers. There was another battery connected with the double-circuit instrument and the visual signal. Said last-named battery, with its connections with the double-circuit instrument, were suitable mechanical means for operating the visual signal.

365 Cross-int. 18. In the application made at Wallingford, as described in page 107, defendants' evidence, how many batteries were used?

Ans. There was one battery connected with both the raise and reverse magnets of two double-circuit instruments, and four raise and reverse track circuit-closers, two of each kind, and with an audible signal.

There was also a battery connected to and with the double-circuit instrument and a visual signal; said battery and connection being suitable mechanical means to operate said visual signal.

There was also a third battery, placed in connection with a double-circuit instrument and a audible signal at a remote crossing, from where the first signal house and bell were placed.

Cross-int. 19. On page 124, defendants' printed evidence, you speak of an experiment made at New Haven, in the presence of Charles H. Mansur; is this the same experiment referred to by Mr. Mansur, at the bottom of page 77 and top of page 78, in defendants' printed testimony?

Ans. I have no doubt but that it is the same experiment.

Cross-int. 20. On page 127 of the defendant's printed testimony you speak of a sketch that you took to Boston and showed to Mr. Hatch; do you know where that sketch is, and when did you last see it?

Ans. I do not know where it is; I do not recollect of seeing it after showing it to Mr. Hatch, at the time mentioned; this was a rough sketch, showing substantially the improved application, as illustrated by Exhibits Nos. 5 and 6; I believe that I left that sketch with either Mr. Hatch or Mr. Rowell, who had charge of the signals on the road.

Cross-int. 21. When were Exhibits Nos. 5 and 6 made, and by whom, and under whose direction?

366 Ans. They were made under and by my direction; Exhibit No. 6 was made by George H. Snow, and the plan of wires was made from those that are now in our shop at Meriden, or substantially so; the same being put there by my son in December, 1872.

Exhibit No. 5 was made by both Mr. C. H. Mansur and George H. Snow.

These exhibits were both made some time during the past winter.

Cross-int. 22. You say in your last answer that the plan of wires was made from the wires now in your shop, or substantially so. What difference, if any, is there, or was there at the time of making this plan or sketch, between it and the wires actually there?

Ans. In place of the connection to the double-circuit instrument No. 1, nearest the battery, in Exhibit No. 6, these wires connect with a danger signal placed upon a frame on the floor, said danger signal being like Exhibit No. 17. Said branch wires were extended to said signal by means of other wires being connected with them. There are wires to connect with two hand instruments, and with the raise and reverse magnets of Exhibit No. 17.

None of these are represented in the diagram.

Cross-int. 23. In your testimony, page 129, defendants' printed testimony, you speak of placing an air cushion circuit-closer on the track of the Hartford & New Haven R. R. Co. Is this the same placing spoken of by G. H. Snow in his answer to cross-int. 67, on page 68, defendants' printed testimony?

Ans. It was the same track instrument. At the time mentioned by Mr. Snow we connected it for one day with the wires that we had erected on telegraph poles leading to our shop, and connecting with our improved signal system that we had there in our shop at that time. During this experiment on the day mentioned I kept a man at the railroad crossing for the purpose of reversing the signals by hand that the down trains would put in operation after they had passed the crossing.

367 We connected the wires that afternoon with the track instrument, and I had wires extending to it, and branch wires connected therewith in such a way that I could at any time make a change by disconnecting this track circuit-closing instrument from the crossing signals and connect my branch wires to the main wires leading into our model room. This arrangement continued until I had finished a second atmospheric track instrument, when I placed it at a point on the down track a few rods above the first one, and connected it directly with the wires leading to our signal instruments and battery in our model room.

This last-named instrument remained in its position for at least six months, I should say.

Cross-int. 24. Have you any means of fixing the date of so first connecting the first atmospheric track circuit-closer mentioned with the wires in the model room more definitely than Mr. Snow has done?

Ans. I think I have. I am strongly impressed that I have a letter

from the man who had charge of the signals on the Hartford & New Haven R. R., in which he states that it was the 22d day of April that it was done.

Cross-int 25. Will you produce it and annex it to your testimony?

Ans. I will endeavor to do so.

Cross-int. 25. Will you produce it and annex it to your testimony?

Ans. I will endeavor to do so.

Adjourned to July 6th, 9.40 a. m.

368 NEW HAVEN, *July 6th*, 1877.

Parties represented by counsel, as heretofore.

Examination of T. S. HALL resumed:

Cross-int. 26. Have you found the letter referred to in your last answer?

Ans. I have found it, and here it is.

Cross-int. 27. Can you now state the date of said first application?

Ans. I can only state that it was in the month of April, 1873.

Cross-int. 28. Do you know of any way in which you, or any one else, can fix that date definitely?

Ans. Not positively, as to the day, but I am impressed that I can definitely ascertain that fact.

Cross-int. 29. In what way, or from whom do you think you can so ascertain it?

Ans. I am strongly impressed, that I have been told by some person employed by me, that they had a memorandum of the day that our first air-cushion track circuit-closing instrument was applied on the Hartford and New Haven R. R., and that that day was the 22d day of April, 1873.

Cross-int. 30. Can you state with accuracy, whether this first air-cushion track circuit-closer was first placed on said track, to enable you to connect it with the wires in your shop, as stated, or before that time, in connection with a highway crossing-signal?

Ans. I can state positively that we connected the first air-cushion track instrument, placed in connection with the down track of the Hartford and New Haven R. R., in the month of April, 1873; and this instrument was placed in connection with wires leading to our shop, and connected with Exhibits 16 and 17, before connect-

369 ing the same instrument with the highway crossing signal on the railroad.

Cross-int. 31. In the years 1872, 1873, and 1874, were Mr. Charles H. Mansur and George H. Snow, in your individual employment, or in the employment of the corporation or corporations which you were connected with during that time?

Ans. In all cases, in giving my direct testimony and also in my cross-examination, where I have used the words employed by *me*, I have intended to convey the idea *by me, or myself as manager* and *representative* of the company organization which I represented at the same time. They were employed by me as manager of the corporations I represented, and not by me individually.

Cross-int. 32. Will you prepare and annex to your deposition a

diagram showing the arrangement described on pages 130 and 131, defendants' printed testimony.

Ans. I will.

(Complainants place in evidence diagram called for, which is marked Exhibit L, E. E. M., Ex'r, July 7, 1877.)

Re-examined by Mr. BALDWIN:

Re-ex. 33. Did you in the year 1873, take steps to procure an English patent for the apparatus and invention afterwards patented by patent 150,030, Exhibit No. 11?

Ans. I did.

Re-ex. 34. Who prepared your papers and specification for the said English patent?

Ans. My attorneys, Messrs. Van Santvoord & Hauff.

Re-ex. 35. Do you recollect the time in 1873, when Van Santvoord & Hauff completed the papers and specifications for the English patent?

370 Ans. I should say in September or October, 1873.

Re-ex. 36. Did those papers describe the one-battery system?

Ans. Fully so.

Recross-examined by Mr. PERKINS:

Recross-int. 37. Did you obtain letters patent in England for said invention?

Ans. I did, in connection with Mr. A. Lines Van Blarcan, who is in partnership with me in my foreign patents.

Recross-int. 38. Was the invention described in your application for your said English patent the same in all respects as the invention described in American letters patent, Exhibit No. 11?

Ans. No, sir. It was not.

Recross-int. 39. Was the application for said English patent the same as the original application which you made for Exhibit No. 11?

Ans. The application for the English patent was precisely the same as the first application made for Exhibit 11, so far as the utilizing one battery for an indefinite number of signals was concerned. It also embraced other devices in connection with my patents, which had previously been patented by myself in this country. I believe, however, that this English patent also embraced the improved air cushion track circuit closer which was patented by Geo. H. Snow, Oct. 21, 1873, and assigned to the Hall Railway Signal Company. There may be some other details, which I do not now recollect.

Recross-int. 40. Were the specifications and claims of Exhibit 11 the same as the specification and claims set out in your first application therefor, as originally made?

Ans. I think not. I think that my claims were reduced,
371 in consequence of another patent that had been issued previously. Owing to my illness at that time, I am not able to give the exact details without referring to the original application.

THOMAS S. HALL.

Subscribed and sworn to before me this 7th day of July, 1877.
EDWIN E. MARVIN, *Ex'r.*

Re-examination of ALVAH W. HALL, resumed:

I have read over my answer to re-ex. 95, as printed on page 39, defendants' printed testimony, and I do not desire to add or alter anything except to strike out the word "first," in folio 149, and put in place thereof the word "these."

ALVAH W. HALL

Subscribed and sworn to before me this 7th day of July, 1877.
EDWIN E. MARVIN, *Ex'r.*

372 NEW YORK, *Jan.* 10, 1879.

Defendant's testimony resumed.

Present: Mr. Van Santvoord, for the complainant, and Mr. Chamberlin, for the defendant.

Defendant's counsel offers in evidence the following British letters patent, copies of which are produced, as follows, viz:

No. 305—Granted to U. Bianchi in the year 1854; which is marked "Exhibit Bianchi No. 42. E. E. M., Ex'r.

No. 2660—Granted to W. Bull in the year 1860; which is marked "Exhibit Bull No. 43. E. E. M., Ex'r.

No. 2807—Granted to W. Clark in the year 1861; which is marked "Exhibit Clark No. 44. E. E. M., Ex'r.

No. 2574—Granted to J. Imray in the year 1862; which is marked Exhibit Imray No. 45. E. E. M., Ex'r.

No. 447—Granted to Barnes & Hancock in the year 1868; which is marked "Exhibit Hancock No. 46. E. E. M., Ex'r."

Also letters patent of the United States, copies of which are produced, as follows, viz:

No. 130,612—Granted to Warner & Odell August 20, 1872; which is marked "Exhibit No. 47. E. E. M., Ex'r."

No. 130,776—Granted to Warner & Odell Aug. 20, 1872; which is marked "Exhibit No. 48. E. E. M., Ex'r."

373 (Counsel for complainants object to the admission of the last patent and exhibit, for the reason that the same is not named in the answer.)

Professor HENRY MORTON, a witness produced on the part of the defendants, being duly sworn, in answer to questions proposed by Mr. VAN SANTVOORD, says as follows:

Int. Please state your name, age, residence, and occupation.

A. 1. Henry Morton; I am 42 years of age; I reside in the city of Hoboken, in the State of New Jersey; and I am the president of the Stevens' Institute of Technology in that place.

Int. 2. State what attention you have given, and during what time, to the subject of electricity, and its applications in the arts, and also state if you have published anything on these subjects?

A. For the last twenty years my time has been chiefly occupied with the study of subjects of chemistry and physics, in which elec-

tricity was an important part, and in experiments and researches in connection with the same subjects.

As regards the special subject of electricity, I have devoted much of my time to it, having accumulated during the period mentioned a large collection of electrical apparatus of my own, in addition to that which has been or is at my command in the cabinets of the University of Pennsylvania, where I was formerly professor of chemistry, and of the Stevens' Institute of Technology.

I have from time to time published in various scientific journals in this country and abroad articles upon electric apparatus and original researches of my own connected therewith.

374 I was employed to write, and wrote the article on electricity in the "New Johnson's Encyclopædia," recently published in New York.

Int. 3. Have you heretofore been called to act as an expert in cases in the U. S. courts on the subjects of electricity and magnetism?

A. I have, in several instances.

Int. 4. Have you read and do you understand "Comp'ts' Patent No. 140,536"?

A. I have, and believe that I do.

Int. 5. Have you read the testimony of F. L. Pope and M. G. Farmer in this suit, and have you examined the sketch, "Compl'ts' Exhibit C," referred to in their testimony?

A. I have.

Int. 6. Have you examined Defendants' Exhibits No. 1 A, 2, 4, 5, 6, 8, 10, 15, 34, 35, 36, and 41, in connection with the descriptions which are given thereof in the testimony in this case on the part of defendants?

A. I have.

Int. 7. Have you read and examined British letters patent No. 305 of 1854, No. 2660 of 1860, No. 2807 of 1861, No. 2574 of 1862, No. 447 of 1868, marked Defendants' Exhibits Bianchi, Bull, Clark, Imray, and Hancock?

A. I have.

Int. 8. Please state whether or not, in your opinion, any person skilled in the art or science to which complainants' patent No. 140,536 relates would be enabled, by following the specification and drawing of said patent of complainant, to construct and apply to use, without further experiment or invention, a successful electric signalling apparatus for railroads, and give your reasons for any opinion you may express.

A. I should not consider it possible for any one skilled in
375 the art to which this patent relates, by following its directions without further experiment or invention, to construct a successful electric signalling apparatus.

My reasons are the following:

1st. The patent does not even purport to be a description of a practical signalling apparatus, but only such a general sketch or suggestion as to the arrangement of the parts as would leave to the person attempting to put it in practice the selection or invention of each and every detail required.

Thus, in reference to the signals, the patent states "M, M^1, and M^2 are the electro-magnets, which actuate or display the signals." (M, M^1, and M^2 in the drawing, or rather diagram, being simply pairs of double concentric circles, thus, ◎ ◎, showing nothing of the construction or attachment of the parts necessary to accomplish any result.) "The said signals may be of any suitable construction, and should be provided with some suitable means of retaining them in position or action after the circuit through the magnets M, M^1, and M^2 has been interrupted."

Again, the patent says: "The respective resistances of the several circuits should be so adjusted that they will be as nearly as possible equal to each other, as a much more perfect action of the apparatus will be secured thereby."

The same description of general principles, and absence of description of the means by which the desired end is to be obtained, characterizes the patent throughout.

The person attempting, therefore, to put the system in practice would be obliged to select from the numerous plans proposed by earlier inventors such as he might judge most likely to answer, and then find out by experiment whether they would operate
376 successfully in this connection, or he would have to invent for himself new means of accomplishing these results.

2d. The patent says nothing whatever about insulating the portions of track connected with the wires from the earth, but only alludes to the insulation of their ends from the rest of the track.

Yet this problem of insulation would be one of excessive difficulty, if not indeed incapable of any successful solution in practice. We all know that in telegraph lines, where the wires are supported on high poles far from the ground, the successful insulation of the line is not at all times attainable.

What, then, is to be thought of the practicability of a system which takes for granted, without even a word of reference, the insulation of portions of a railroad track close to the ground requiring the most solid possible support, and exposed to every possible cause of failure from dirt, moisture, and the like? I am convinced that this difficulty alone would be fatal to the successful carrying out of the plan proposed in the patent.

(The testimony under this 2d head was objected to by complainants' counsel as irresponsive, speculative, and argumentative.)

3d. The general arrangement proposed in this patent as to the conductors I also conceive to be a very bad one, and calculated to interfere with the successful operation of the system on a practical scale.

Thus, according to the patent, two parallel conductors are to be carried from the battery along the line of the road, and so connected with the points at which the circuit is closed that each successive closure, proceeding outward from the battery, will involve a
377 great increase in the length of wire traversed by the current, and a consequent enfeeblement of its effect. If, therefore, the magnets were all alike, this would bring about the result that a bat-

tery sufficient to operate the nearer ones would be unable to operate those more distant, or, if strong enough for the more distant, would destroy the connections of the nearer ones, unless some arrangement were made to equalize the resistances of the various circuits, as suggested in the patent.

Such equalization of resistances could, it is true, be effected by well-known means, such as the introduction of resistance coils into the nearer circuits, but this would involve expensive additions to the apparatus, liable to derangement, and which would all have to be specially adjusted to each given line, and all of which would require change, if an alteration in the line was made at any time.

The patentee seems to have realized this difficulty, for he suggests a relief for it by having a number of batteries attached at convenient intervals along the line. In this case he adds: "The principle of operation will remain the same as that heretofore described," forgetting, apparently, that he had already described the essence of his invention as consisting in "obviating the inconvenience and expense of employing, as heretofore, one or more separate batteries, situated at or near each signal, for the purpose of actuating the same."

In the above answer I, of course, exclude from consideration, as part of the state of the art at the date of the complainants' patent, those inventions and experiments already made and carried into practical operation by defendant, which, as I understand them, anticipate the claims of complainants' patent.

If, in place of the general and indefinite suggestions of com-
378 plainants' patent, the various devices made and used by defendant are inserted, then, as far as they go, they would enable one skilled in the art to carry out the system practically.

(The testimony under the 3d head was objected to by the complainants' counsel, as the expression of an opinion not called for, and an uncalled-for statement of what the witness understands to be "of course" excluded.)

Int. 9. Does complainants' patent describe or make known any means or plan for adjusting or equalizing the resistances of the different circuits described in it?

A. It does not.

Int. 10. Please state whether or not, in your opinion, there would be any difficulties in applying on the line of a railroad the method described in complainants' patent for signalling by means of electricity, apart from the supposed signals and their connections; and, if there would be, please state such difficulties, and give your reasons for any opinion you may express.

(Objected to, as calling for an opinion upon a subject not in issue.)

A. As I have already noticed in a previous answer, there would be, as I believe, two main sources of difficulty, one consisting in the maintenance of insulation between the portions of the track connected with the several circuits. These being of necessity placed close to the ground, and requiring very firm attachment to the

sleepers, the cost and difficulty of even attempting to insulate them from each other, or, what amounts to the same thing, from the ground, would be very great, and, even if accomplished, would
379 be impossible to maintain during wet weather, and very liable to be destroyed at other times by various causes—such as the presence of dirt or any conducting body which might form an electric connection between the earth and the insulated track.

For injurious effects to follow, it would not be necessary that both tracks in the same section of insulated track should be connected with the earth, but if any one rail connected with the positive wire lost its insulation from the ground, and any one rail connected with the negative wire also lost its insulation, the whole system would be rendered useless.

In the second place, I consider that the necessity for equalizing the resistance of the various unequal circuits involved in this system would involve trouble and expense, and a liability to derangement, which would constitute serious practical objections to this plan.

Int. 11. Please compare complainants' patent with a copy of Complainants' Exhibit C, and state whether or not you find the two systems shown and described therein to be alike; and, if not alike, what differences do you find between them?

A. I find the system shown in the drawing Exhibit C to differ from that described in complainants' patent in several important particulars; in the first place, the drawing Exhibit C does not show a method of closing the battery circuits and thereby actuating the signals by means of insulated sections of railroad track, as described in complainants' patent, but as closed by some independent circuit-closing apparatus not mentioned in the patent.

In the second place, I do not find in the drawing any indication of the two or more electro-magnets M, M^1, M^2, for actuating the signals, nor of the two or more electro-magnets m, m^1 m^2, for
380 releasing the signals, as called for in the description and claims in said patent.

Admitting that this is an oversight, and that the drawing might be further continued or duplicated, so as to introduce another station with its pair of magnets, we should then have another discrepancy, for there would then be several circuits—that is, the circuit from the battery to the first station—to the second station, etc., including, of course, return to battery or connection with the earth in each case, which, according to the plan actually in use (and which would then be correctly represented by the drawing, with the additions I have suggested), would be all exactly equal, and would, therefore, neither require nor admit of adjustment of their resistances.

The plan described in the patent, however, would of necessity produce circuits, all of which differed in resistance, and would require an adjustment to equalize them, as the patent itself states.

I also find a difference between the plan described in the patent and that shown in Exhibit C in another regard; in the plan of the patent the conductors C and Z are connected respectively with the positive and negative poles of the battery, or, as the patent itself

states, "are virtually prolongations of the positive and negative poles of the battery."

In the plan shown in Exhibit C, however, the conductor C, or positive conductor only, is connected with the battery, the other conductor, Z, or, as it is called, negative conductor, having no connection with the battery. In consequence of this difference of arrangement in the system of the patent, the positive conductor C carries the positive current in one direction away from the battery; and the other, or negative conductor Z, brings the positive current in the opposite direction, or back to the battery, and thereby
381 involves the production of circuits of different resistance for each station. In the system represented in Exhibit C, on the other hand, both the conductors C and Z serve to carry the positive current in the same direction away from the battery, and should, therefore, properly be both called positive conductors. As a result of this arrangement the current always passes through the same or equal circuits, no matter at which station the connection is made, simply changing from one to the other of these equal parallel wires at the station where the contact is effected.

It is for this reason that in this system no equalization of resistances, in the sense involved in the description of the patent, is required.

Int. 12. Please state whether you find in the English patent of Bianchi the invention, or any material part of it, which is described in complainants' patent and specified in the several claims thereof, and specify the same, and give your reasons for any opinions you may express?

A. In this patent of Bianchi I find the following, which I regard as important features of complainants' patent: The use of a single battery in combination with two or more instruments for interrupting and renewing electric connection, in combination also with two or more electro-magnets, actuating, or causing to be actuated, visible or audible signals, capable of attracting the attention of an engine-driver on a train. To effect this object the following arrangements are adopted. I quote from the patent, page 3, line 25, *et sequitur*:

"I place an insulated telegraphic wire along the line of railway between two stations, and I connect it with a series of appa-
382 tus, which I call interrupters, which are placed at intervals (say, of a mile or half a mile) along the line. These interrupters are so arranged that the continuity of the wire is broken or interrupted whenever a train passes, as hereinafter described. The wire is connected with an electro-magnet at each station, and with a galvanic battery or other source of electricity at one or both stations, and finally is placed in connection with the earth at each station. A current of electricity is thus constantly passing from the battery through the electro-magnets and line wire, and back through the earth to the battery. The armatures of the electro-magnets are thus constantly attracted towards them, and remain motionless. If now a train passes along the line, it will cause a momentary interruption of the current of electricity as it passes each interrupter.

At each interruption the armatures are drawn away from their respective electro-magnets by means of springs, and are immediately attracted back again. Each motion of the armature allows the passage of one tooth of an escapement wheel, which has as many teeth as there are interrupters in the line wire. This wheel will therefore make one revolution while the train passes from one station to another, and will thus indicate at each station the passage of the train past each of the interrupters."

Also, from page 5, line 5:

"In order to call attention to the apparatus when it is put in action by a train leaving the opposite station, an alarum and and a moveable signal are added to the apparatus, *i* is a sliding rod or
383 wire, which carries a small plate, on which may be inscribed the word DEPARTURE."

Also, pages 6 and 7, beginning at line 18, p. 6, as follows:

"Figure 7, sheet II, is a vertical section of one of the interrupting apparatus hereinbefore mentioned; figure 8 is an end view of the same, and figure 9 is a side elevation of the same. The apparatus consists of a cast-iron box Z, one of whose sides is capable of being removed to obtain access to the interior; *a* is a lever, made of tee-iron, and turning upon a fulcrum *b*, and working through a slit in the top of the box; *k* and k^1 are two cylindrical boxes containing helical springs *l* l^1, which force the lever *a* upwards. The lever *a* is connected by a short connecting-rod to a small lever *c*, which carries a wire *d*, which dips into a cup *e* containing mercury. The wire *d* is soldered or otherwise put in connection with the wire *q*, which is covered with gutta-percha to insulate it. This wire *q* is part of the line wire, which is supported upon posts or otherwise fixed and insulated like the ordinary line wire used for electric telegraphic purposes; *v* is a wire dipping into the mercury-cup *e*, and connected with the continuation of the line wire. The current of electricity thus passes along the line wire until it arrives at *q*, and it then passes through the wire *d* and the mercury in *e* to the wire *v*, and then continues its course along the line until it enters the next interrupter, and so on, passing through all the interrupters until it arrives at the opposite station. If, now, the lever *a* of any one of the inter-
384 rupters be depressed, the wire *d* will be lifted out of the mercury, and the conducting contact being thus broken, the apparatus hereinbefore described, which are placed at each end of the line wire, will be brought into action in the manner hereinbefore described. The depression of the levers *a* is affected by a roller or wheel *g*, Figure 7, which is attached by a support or bracket to the frame of the locomotive engine, and projects from its side. The line *h* shows the course or path of the roller *g*."

Also, pages 7 and 8, beginning at line 28, on p. 7, as follows:

"The next described aparatus is intended for conveying signals from the stations at each end of a section of line to the intermediate points at which the watchmen or signal men are placed to warn the trains of danger and to guard the line. One of these apparatus is

indicated at Y in Figure 10, sheet II, being placed in a small shed or watch-box. A separate line wire is employed for these apparatus, as shown at *b*, in Figures 10 and 12.

"Figure 13, sheet III, is a front view of one of these apparatus, and Figure 15 is a similar view, with the front of the apparatus removed. Figure 14 is an end view, with the end of the case removed. This apparatus consists of an alarum and a moveable signal very similar in construction to those already hereinbefore described. A is an electro-magnet provided with an armature *a* attached to a lever *c*, which turns on a pivot *e*. The armature is drawn
385 away from the magnet by a spring when the current is interrupted, but it remains in contact or close proximity to the magnet when the apparatus is at rest, a constant electric current being maintained in the line wire, and through the apparatus. The lever *c* carries a stop or detent which locks the wheel *n*, and prevents it from being driven round by the spring barrel *o*. When the current is interrupted, the detent is withdrawn from the wheel *n*, which is immediately driven round by the spring barrel *o*, and communicates motion by toothed wheels to the hammers *h*, which strike upon the bell *p*, and thus call the attention of the signal man. K is a small plate, on which may be inscribed the word danger, and which is retained by a small fork on the end of the lever *c*. The same motion of the lever *c* which releases the alarum also releases the signal plate K, which is thrown out by a spring into a horizontal position, as shown in Figure 13. The attention of the signal man is thus called by both an audible and a visible signal. In order to enable the signal men to communicate information of danger to the stations, and to one another, a small button, shown at *q*, in Figure 13, is added to the apparatus, by means of which the signal men can interrupt the current in the wire, and thus ring all the alarums and exhibit the signals at the stations, and also at all the intermediate points. In Figure 12, sheet II, *a*, *a*, are the commutators or interrupters at one of the stations, and *c* is that at another station. Any
386 simple commutator or interrupter may be employed for this purpose. In lieu of or in addition to the small signal plate for calling the attention of the signal man, a large signal may be displayed by the apparatus, so as to attract the attention of the driver or guard of an approaching train."

Also, from p. 9, lines 22 and 23:

"It is thus only necessary to have a galvanic battery at every alternate station."

Also, p. 11, lines 3 to 15, as follows:

"Secondly. The constructing and arranging electrical apparatus at the stations, and at the positions of the watchmen or signal men, so that such several apparatus may be traversed by a continuous current of electricity, and be capable of communicating signals from any one of such apparatus or instruments to all the others by momentarily or temporarily interrupting the continuity of the wire one or more times in succession, as hereinbefore described; also, the ar-

ranging such apparatus so as to display signals capable of attracting the attention of the engine-driver or other persons on the train.

"Thirdly. The mode of combining the various apparatus hereinbefore described, and arranging them so as to be worked by one and the same galvanic battery, as hereinbefore described in reference to Figure 12, sheet II."

Int. 13. Please make the same comparison of the complainants' patent with the British patent to Bull.

A. I find in this patent of Wm. Bull that material part of
387 the invention in the complainant's patent, which consists in insulating sections of the rail and then making use of them to close a battery circuit through the wheels of a passing train, whereby an electro-magnet was caused to actuate a signal. This I find described in the above-mentioned patent, on page 5, line 27 to line 38, and page 6, line 12 to line 20. I quote:

"Between the ends of the rails, and also between the joint-plates and rail-ends, I insert a thin piece of leather, millboard, gutta-percha, or other suitable substance for cutting off metallic contact (at such parts of the line as it is required to indicate the passage of the trains) and thereby insulate one rail of twenty feet, more or less, as may be necessary. The rails or portion of metals so insulated I either connect with the line wires or with a wire at the side of the line, which I denominate the permanent-way wire or progressive-motion-indicator wire. At the stations at which it is required that the progress of the train shall be indicated a battery is fixed, and in connection therewith a dial or indicator, both of which are also connected with the line permanent-way wire, the terminals of which are the pairs of insulated rails, as before described."

"Now, suppose a train to be starting from the terminus *k*, and the hand of the dial in the position shown, and the permanent-way wire in connection with the battery at the station *l*, when the train arrives at the contact-point 1 on the line the electric circuit would be completed by the wheels of the engine connecting the two insu-
388 lated rails, (one in connection with the line or permanent-way wire and the other with the earth,) when the current would flow and actuate the electro-magnetic armature, and thereby relieve the pawl and ratchet, when the hand on the indicator will move to the point 1 on the dial."

Int. 14. Please make the same comparison as in question 12 between complainant's patent and the British provisional patent to Clark.

A. I find in this application that material part of the invention set forth in the complainant's patent which describes the combination of a galvanic battery, conducting wires and electro-magnets for reversing signals, with circuit-closing apparatus placed at intervals along a railroad, also the locking or holding in position of the danger signal until released by the above-mentioned action of the electro-magnet. This I find described in said application, page 1, lines 10 to 23. I quote:

"This invention relates to electrical apparatus intended to ensure the safety of railway trains. These electrical apparatus are of two kinds: 1st, apparatus placed on the line; & 2nd, apparatus to be placed near stations. The first apparatus which is placed on the line is worked thus: The locomotive or tender in passing a signal disc oscillates a treadle or lever which turns the disc to red and indicates the line blocked; at the same time the locomotive raises a weight which prevents the treadle rising during the passage of the train over the part of the line governed by the said treadle and disc. The disc thus remains indicating line blocked until
389 the train has arrived at the next disc, there it again oscillates a second treadle which turns the second disc to red, but here the movement of the disc establishes an electric or magnetic current which controls the first disc and returns it to the indication of (line clear). Thus all the discs being in communication with one another it is easily known if a preceding train has cleared the distance between any two discs."

Int. 15. Please make the same comparison as in int. 12 between complainants' patent and the British patent to Imray and specify the same.

A. I find in this specification that material part of the invention set forth in the complainants' patent, which consists in the combination of a battery, conducting wires, electro-magnets, actuating signals, and circuit-closing devices placed at intervals along the line of a railroad; the arrangement by which this is effected I find described in general terms in said specification on page 5, lines 16 to 39, and page 6, lines 1 to 10. I quote:

"The improvements apply, in the first place, to apparatus for actuating the distance signals of railways, and for securing their correct action by means of electricity. For this purpose on the column of the distance signal I mount a vane, disc, arm, or colored light, which, when it is turned in one direction, shall indicate that the line is clear, and when turned partly round into another position shall indicate that the line is stopped, or that it is unsafe for a train to proceed farther. I arrange in the column suitable clockwork of ordinary construction to act by a spring or weight, and I keep the same
390 constantly wound up and ready to turn the vane or light when a detent is withdrawn. This detent is acted on by electro-magnetic apparatus connected by conducting wires with the station or place from which the signal is to be worked, so that an operator, by moving a suitable handle when he desires to stop a train, introduces a battery into the circuit which actuates the electro-magnetic apparatus, and causes the detent to be withdrawn. In combination with this arrangement there are placed at the station or elsewhere bells, also connected with electro-magnetic apparatus and the conducting wires, so that when the battery is put in connection with the signal circuit the bells commence to ring, and to continue to do so until the distance signal has moved to its new position, when they cease to sound in consequence of the electric current being cut off from the magneto-electric apparatus of the bells by the change of position of the vane

of the distance signal breaking contact with the wire that communicates with the bell apparatus. I also arrange miniature vanes at the station or place where the operator is situated which by the action that stops the ringing of the bells are caused to turn to a position corresponding to that of the distance signal they represent, so as to show that it has obeyed.

"I sometimes connect the distance signals with instruments which I fix along the line to be acted on by passing trains, so as to make or break contact and work the electro-magnetic apparatus in such a manner that a train, on passing one of these instruments, actuates a lever or arm connected with the electric wires of the signal,
391 and thus makes or breaks contact, which causes the signal to be moved so as to indicate that the line is closed, until an attendant or the train in passing a further instrument causes the signal to be moved again, so as to indicate that the line is clear."

Int. 16. Please make the same comparison as in int. 12, between complainants' patent and the British patent of Barnes & Hancock.

A. In this provisional specification I find that material part of the invention set forth in the complainants' patent, which consists in the combination of a battery, conducting wires, and electro-magnets or magnets, actuating signals, with two or more circuit-closers, consisting of insulated portions of the rail, which are to be connected by the wheels and axles of a passing train, these being placed at intervals along the line of a railroad.

The description of this I find in said specification from the line 12 to the end. I quote as follows:

"The first part of our invention consists in connecting the two poles of a battery with the two rails, the junction of the two being only completed at the time the wheels of a carriage, united by their axles, pass over the two rails, so that at all times, except when a carriage or carriages is or are on the line of rails, the circuit will not be complete, but so long as a carriage remains on them the battery will act. Between one wire uniting one rail and the battery we place a magnet, which acts against, or which is capable of acting on a lever (of course when the circuit is complete), and this lever is connected with a rod leading to the semaphore arms or other signal on a post. As soon as the wheels of an engine, truck, or car-
392 riage place the battery in action by completing the circuit, the magnet attracts the lever, which throws the signal to danger; so long as the carriages remain on the line the circuit will still be maintained, but as soon as the circuit is broken the battery will cease to act, and a weighted lever throws the signal to clear or caution as desired.

"This is effected, and in this the second part of our invention consists, in the following manner: At the post, or at a short distance in advance thereof, if preferred, we disconnect one rail from the other, we divide as it were the two rails, leaving a space between them, no matter how small that space may be. As an engine, for example, approaches the junction the signal is at clear (the battery not being in action), but the instant the wheels cross the space dividing the

rails the circuit is completed, the magnet acts, and the signal is thrown to danger. So long as the engine or train remains on these rails so long will the signal continue at danger, but as soon as the last wheels of the last carriage have past over the next division in the rails the circuit is broken, and the weighted lever is free to throw the signal to clear. Of course the distances between the divisions in the rails may be regulated according to the distance it is desired to place the signals apart, the signal acting equally well whether the distance be a quarter of a mile or ten miles."

Int. 17. Please make the same comparison as in int. 12 between complainants' patent and Defendants' Exhibit 1 A.

393 A. In this exhibit I find represented that material part of the invention, set forth in complainant's patent, consisting in the combination of a battery, conducting wires, circuit-closers, and an electro-magnet, for actuating visible or audible signals, with circuit-closers, conductors, and an electro-magnet for reversing, releasing, or stopping said signals, being what is specified in the third claim of the complainants' patent.

(Last clause of answer objected to by complainants' counsel as being for the judge to say.)

Int. 18. Please make the same comparison as in int. 12 between complainants' patent and Defendants' Exhibit 2.

A. In Defendants' Exhibit 2 I find represented that material part of the invention set forth in complainants' patent, which consists in a battery, in combination with positive and negative conductors, two or more electro-magnets for actuating, or causing to be actuated, visible or audible signals, and two or more circuit-closers; also the combination of the same battery with positive or negative conductors, two or more electro-magnets for releasing or reversing visible or audible signals, and two or more circuit-closers; in other words, I find in this exhibit everything that is specified in the claims of complainants' patent, with the exception that the circuit-closing devices are collected together, and are not placed at intervals along the line of a railroad.

At 5 p. m. adjourned to January 11th, 1879, at 10 a. m.

394 NEW YORK, *January 11th*, 1879.

Defendants' testimony resumed.

Present: Mr. Van Santvoord, for complainants, and Mr. Chamberlin, for the defendants.

Testimony of Prof. HENRY MORTON continued.

Int. 19. Please make the same comparison as in int. 12 between complainants' patent and Defendants' Exhibits Nos. 4, 9, 27, 36, and 41.

A. I find in each of said exhibits, taken in connection with the description thereof in defendants' testimony, all the material features set forth in the third claim of complainanants' patent, and also all

those features of the first and second claims of said patent, which are shown in the drawing, Complainants' Exhibit C.

Int. 20. Please make the same comparison as in int. 12 between complainants' patent and Defendants' Exhibits Nos. 5, 6, and 10.

A. I find in each of said exhibits, taken in connection with the description thereof in defendants' testimony, every material feature set forth in the claims first, second, and third of complainants' patent, and everything shown in the drawing accompanying said patent, with the exception that the circuit-closers, as indicated in Defendants' Exhibits 5, 6, and 10, are not made by the use of insulated portions of track, but by more efficient and reliable means.

Int. 21. Please make the same comparison as in int. 12 between complainants' patent and Defendants' Exhibit 8.

A. I find Defendants' Exhibit No. 8 to contain every ma-
395 terial feature set forth in the three claims of complainants' patent, with the addition of several important additions, such as the provision for a safety as well as a danger signal.

Compared with the specifications of the complainants' patent, it also presents the important improvements or desirable differences of avoiding the use of insulated portions of track for circuit-closers, and also of avoiding the establishment of circuits of unequal resistances.

Int. 22. Assuming the existence of such a system as is represented by Defendants' Exhibits Nos. 5 and 6, would it involve invention to equalize the unequal resistances of the various circuits, therein shown, by any of the well-known means, such as resistance coils or the like, for equalizing resistances; and give your reasons for any opinion you may express?

A. Assuming the existence of the system shown in Defendants' Exhibits Nos. 5 and 6, as explained by the testimony of defendants' witnesses relating to the same, and establishing the respective dates of the inventions there shown, it would not involve invention to equalize the unequal resistances of the various circuits which would exist in such a system, by any of the well-known means, such as resistance coils, or the like.

Prior to any experiment with such a system, it would be perfectly plain that these differences of resistance in the various circuits would exist, but it would not follow, until established by experiment, that they would necessarily interfere with the successful working of the system on a practical scale.

It was only when experience had demonstrated that a battery strong enough to operate the most distant magnet, and therefore, through the highest resistance, would destroy the connections
396 of the circuit-closers, that this practical difficulty would become manifest, but the moment it appeared, it would follow, as a matter of course, that this difficulty could be overcome by the familiar process of equalizing resistances by the use of resistance coils and the like; these resistance coils had been in constant use for the purpose of equalizing resistances in circuits for a long time prior to the date indicated, and in a multitude of instruments.

Int. 23. Assuming the existence, at the time you refer to in your

last answer, of such a system as is shown by defendants' said Exhibits Nos. 5 and 6, did it involve invention so as to change the system of connections therein, that all the circuits therein were made equal at first, and would always continue so, no matter what additions or reductions were made to the length of the line operated; and give your reasons for any opinion you may express?

A. Assuming the existence of this system, at the time indicated as before, I consider that it would involve invention so to change the system of connections therein as to render all the circuits equal in length and of equal resistance.

This did not involve the simple introduction of a well-known means for producing the effect for which that means had constantly been employed, but involved a radical change in the entire system of connections employed in carrying out the invention, and was really a problem which, when first presented, would seem to offer very great difficulties.

Int. 24. Please look at defendants' patent 165,570, Defendants' Exhibit No. 40, and state whether or not you find therein described such a change as is referred to in int. 23 and answer.

A. I do.

Int. 25. State whether or not the system described and
397 shown in Mr. Hall's said patent, Exhibit No. 40, involves the use of the alleged invention or system which is set forth in complainants' patent, on which this suit is brought, and give your reasons for any opinion you may express.

A. The invention described and claimed in this patent consists, as I understand, in the combination with a series of keys or circuit-closers of a battery and two line wires, one line wire being connected with the battery at one end, and the other wire not being connected with the battery, but with the ground at the end of the line furthest from the battery, the remaining pole of the battery also being connected with the ground.

By these means, no matter where along the line of the two wires connection is made from one of them to the other, the circuit established will be equal in length and resistance.

If the connection is made near the battery, the circuit will pass a short distance along the battery wire, which we may call A, and will then traverse the rest of the distance to the earth by the other parallel wire B.

If the connection is made at a greater distance from the battery, then the current going just so much further by the wire A will cross to the wire B, and will have to travel just so much less a distance on that wire before reaching the earth.

Thus, evidently, no matter where the connection is made, the distance traversed will be equal, and the resistance encountered also equal, as this is simply proportional to the length of the wire traversed, when that is all of the same character. In the system set forth in complainants' patent, in so far as it relates to this subject, I find the combination described of a battery with two conducting
wires connected respectively with its opposite poles, and as
398 the specification itself states, "the conductors C and Z are

virtually prolongations of the positive and negative poles of the battery B."

With this arrangement it follows that, when connection is made from one wire to the other at a point near the battery, the current, passing along the wire C, crosses to the other wire Z at this point of connection, and returns to the battery by that wire, thus passing through a circuit, short and therefore of low resistance.

If, on the other hand, the connection between the wires is made at a greater distance from the battery, the current must pass along the conductor C to that more distant point, cross over there to the conductor Z, and return from this greater distance along the wire Z to the battery, thus completing a longer circuit, which is therefore necessarily of higher resistance, the same wires being used in each case.

We have, therefore, in this arrangement nothing whatever corresponding to that which is set forth in defendants' patent No. 165,570—Defendants' Exhibit No. 40—as a means of making all the circuits of equal length and resistance.

It is true that, though nothing in reference to this is stated in the claim, or shown in the drawings of complainants' patent, the specification of the same contains a suggestion that the respective resistances of the several circuits should be so adjusted that they will be as nearly as possible equal to each other.

The only adjustment which could be understood from this statement, in connection with the drawings of the patent, would evidently be the introduction of resistance coils, or the like, into the unequal circuits there shown, which, as I consider, would be an entirely different thing from such an arrangement of equal circuits as is described and claimed in defendants' patent 165,570, Defendant's Exhibit No. 40.

399

Int. 26. Considering the state of the art prior to Mr. Pope's application for his, complainant's, patent, would it involve invention to arrange two or more circuit-closers with magnets for operating signals, and two or more circuit-closers with magnets to withdraw the same signals along the line of a railroad in connection with a signal battery and conductors C and Z attached to the positive and negative poles, respectively, of the battery?

A. It would not. Mr. Hall, the defendant in this case, and possibly others, had developed by their practical experiments all that is involved in such a system as is stated in your question.

Int. 27. Referring to the last part of your answer to int. 8, where you refer to inventions and experiments of defendant, do you refer by the word defendant to Thomas S. Hall? And state also in your answer what you mean where you use the words "exclude from consideration as part of the state of the art at the date of complainants' patent, &c."

A. I do refer to Thomas S. Hall and those concerned with him in the development of his various inventions relating to the present subject. In the passage referred to in my previous answer, I mean to draw attention to the fact that I did not consider inventions made by Mr. Hall and his colleagues, and either patented by them, or competent to have been patented by them, at that time, to be in any

sense part of the state of the art, in reference to another patentee, who might desire to introduce said inventions as subject-matter of a patent for himself.

400 Cross-examined by Mr. CHAMBERLIN:

X-int. 28. In addition to the theoretical knowledge which you have stated in your direct testimony that you have acquired, have you had any experience in the practical construction or operation of electric railway signals?

A. I have not.

X-int. 29. Have you ever been called upon to act as an expert in any courts, with reference to the application of electricity or magnetism to the construction or operation of railway signals?

A. I have not.

X-int. 30. Are you familiar with the state of the art, including foreign publications, patents, and specifications, at date of issue of complainants' patent?

A. To a certain extent.

X-int. 31. Were not electric visual signals of suitable construction to be placed along the line of a railway, which were capable of being put in action or exhibited by the action of one electro-magnet, and reversed or concealed by the action of an another electro-magnet, substantially in the manner and for the purpose set forth in complainants' patent, well known and in public use at the date of said patent, namely, July, 1873?

A. There were many plans proposed for this purpose, but I know of none of them, except those of Mr. Hall, which were in practical and successful operation at that time.

X-int. 32. Were not such electric visual signals of such construction as stated in the last question, and which were capable of being put in action or exhibited by the action of one electro-magnet, and reversed or concealed by the action of another electro-mognet,

401 substantially in the manner and for the purpose set forth in complainants' patent, at that time, clearly set forth and described in printed publications?

A. They were.

X-int. 33. Please state in what publications, with as much definiteness as you are able.

A. I cannot now from memory give you the references, but will at the next session give them with pleasure.

X-int. 34. Please do so on Monday next.

A. I will.

X-int. 35. Please examine the English patent of John Henry Johnson, No. 446, and dated March 5th, 1858, which I now hand you, and say whether or not it contains a drawing or description or both of a visual or a semaphoric signal, intended to be placed on the line of a railroad, which signal is exhibited, or brought into action by the passage of an electric current through the helices of an electro-magnet, which continues exhibited, or in action, after the current through said electro-magnet has been interrupted, and which

is reversed or withdrawn from view by the action of a different current, through another electro-magnet?

A. The statement in your question I conceive to be a correct general description of what is described and claimed in the patent, to which you have referred; not failing to notice that two batteries are to be used in this plan, one for exposing and the other for concealing the signal, and the general arrangement is not such as would be likely to operate successfully in practice.

(The last clause of the answer objected to by the complainants' counsel, as not responsive.)

402 X-int. 36. Please examine the American patent of Frank L. Pope, No. 149,152, dated March 31st, 1874, the application for which was filed December 21st, 1872, which I now hand you, and say whether or not it contains a drawing or description, or both, of a visual or semaphoric signal intended to be placed on the line of a railroad, which signal is exhibited or brought into action by the passage of an electric current through the helices of one electro-magnet which continues exhibited or in action after the current through said electro-magnet has been interrupted, and which is reversed or withdrawn from view through the action of a different current through another electro-magnet.

(Counsel for the defendant objects to the question, as irrelevant and immaterial.)

A. I have examined the patent to which you have called my attention, and find the apparatus therein described and shown to correspond with your statement in reference to it; I would only draw attention to the fact that in this case the signal is set by one battery and released by another at the next station, and that I do not think the successful working of the plan proposed could be safely assumed without a practical trial or experiment.

(The last clause of the answer objected to by the complainants' counsel, as not responsive.)

X-int. 37. Referring to your answer to X-int. 35, would it make any difference whatever, so far as the operation of the electro-magnets and the visual signal described in Johnson's patent are concerned, whether the currents which operate the respective
403 electro-magnets successively were derived from the same or independent batteries, provided the currents themselves were substantially of the same strength.

A. If the apparatus could be made to work at all in practice it would of course work with currents of a given strength, no matter whether they were derived from one battery or from two.

Adjourned to January 13th, 1870, at 10.30 a. m.

NEW YORK, *January* 13, 1879, 10.30 *a. m.*

Present: Counsel as before.

Cross-examination of Prof. MORTON continued.

X-int. 38. Have you brought with you, and can you now furnish the publications called for by cross-interrogatory 33?

A. I have. They are as follows:

In the work entitled, "Traité d'Electricité Théorique et Appliquée," by "A. De La Rive," Paris, 1858, v. 3, p. 489, is described the system of Mr. Walker.

In the work entitled, "L'Electricité et les Chemins de Fer," etc., by "Manuel Fernandez de Castro," Paris, 1859, v. 2, p. 289 *et seq.*, are described the systems of—

Mr. Jonathan Sparrow Crowley.
M. Fragneau, October 28, 1853.
M. Reville.
M. Dumoulin, November, 1856.
M. Markfoy, November, 1857.
M. Lenoir, February 19, 1858.
M. Tyer, January 22, 1852.
MM. Maigrot et Faitot, November, 1852.
Mr. C. F. Farrington, December 21, 1853.
404 M. Vérité, January, 1854.
M. Jules Erckmann, November, 1855.
M. Th. du Monsel, April 29, 1856.
M. Lafollye, 1857.
M. Bergeys, 1857.

In the work entitled "Traité elementaire de Physique Theorique et Experimentale avec les applications a la Meteorologie et aux Arts Industriels," by "P. A. Daguin," Paris, 1861, vol. 3, p. 831, the system of M. Tyer is described.

In the work entitled "Expose des Applications de Electricité," by Le Cte. Th. du Moncel, Paris, recently published, but without printed date, are described in vol. 4, p. 489 *et seq.*, the systems of—

M. Marqfoy.
M. Tyer.
Mr. Preece.
MM. Siemens & Halske.
MM. Lartique, Tesse and Prudhomme.
M. A. Daussien.

In the work entitled "Railway Appliances, &c.," by John Wolfe Barry, New York, 1876, in which, on pages 143 *et seq.*, are described the systems of Mr. C. V. Walker, of Mr. W. H. Preece, and of others not named.

In the work entitled "Der Elektromagnetische Telegraph," by Dr. H. Schellen, Brunswick, 1870, p. 716 *et seq.*, describes the systems of Siemens, Halske, of Bréguet, of Hagendorff, and of Kramer.

Int. 39. Will you please give your reasons for your opinion that the signal represented in Johnson's patent (Ex. M.) would not be likely to operate successfully in practice?

A. In the first place, the mechanical contrivance for operating the signal is such that very great force would need to be expended
405 in moving backward and forward the disk D, which is directed to be made of glass, and is supported at the end of a long lever, at a distance from the fulcrum more than eight times

that at which the power from the other lever, acted on by the magnets, is applied. Whatever force, therefore, was needed to set this disk in motion at a given velocity, eight times as much would have to be applied by this other lever at its end; the end of that lever is at a distance from its fulcrum more than six times as great as is the distance at which the average attractive force of the magnets would act; consequently, whatever force was needed to give motion to the disk, forty-eight times as much force would need to be applied by the magnets.

The duration of the current, by which this force is to be developed, would be limited by the time during which an elastic metal spring, stretched between two supports on a moving truck, carrying a galvanic battery, was in contact with a metallic knob M, fixed at the side of the track, as the train, including this truck, ran by. For an express train this would probably amount to about one-tenth of a second, and if sufficient impulse to set this heavy weight of the glass disk, and its still heavier counterpoise, (which, as shown in the drawing, would have to weigh about three times as much), in motion, overcoming also considerable friction in the various parts was not applied in this time, the apparatus would fail to operate. The difficulty of carrying a battery in a moving train, and of keeping in order such a contact arrangement as indicated, would, of course, be additional drawbacks to the possible success of this system; but I think the mechanical difficulties which I have already pointed out, in connection with the signalling device itself, would be
406 sufficient to secure its failure in practice, as, in order to obtain sufficient power, either a current so powerful as to injure the contact points, or magnets of excessive size and expense would have to be used; and if the apparatus was so adjusted as to operate with a rapidly moving train, it would break itself to pieces with the prolonged contact produced by a slowly moving one.

(The copy of Pope's patent, 149, 152, Exhibit N, is put in by consent, although not certified as a copy.)

X-int. 40. Referring solely to the mechanism shown in Exhibit M for exhibiting and concealing the visual signal by the action of the two magnets J and K, irrespective of the devices there shown and described for generating or transmitting the electric currents for exhibiting and concealing said signal, is there any reason why said mechanism would not operate successfully, provided electric currents of sufficient strength and sufficient duration were sent through the coils of the electro-magnets?

A. I think that there is; as I have already pointed out, the whole apparatus would be very heavy, and would involve considerable friction. The magnets would also operate on the armatures at a great disadvantage, being of necessity at their greatest distance from them when the most force was required; consequently a very powerful attraction would be needed to start the apparatus in motion, and necessarily increasing, would produce a velocity likely to injure the machine itself; the same effect would follow from the momentum of these heavy moving parts, irrespective of the above increase in

attractive force, and indeed I am quite certain that, as a mere mechanical arrangement, this device would not operate in practice. In confirmation of this opinion, I will quote from the patent
407 of Mr. Pope, No. 149,452, Exhibit N, which was shown to me on the last day of this examination, as follows: "In order to move the signal disc G in a prompt and effective manner by means of an electro-magnet, it is necessary to construct it of very light or thin material, such as cloth or paper stretched over a hoop." The disc G, here referred to by Mr. Pope, is not, as in the patent of Johnson, supported at the end of a long bar, but is supported on an axis at its own center, on which it freely rotates. If this requires to be thin and light, what chance is there for a heavy plate of glass, with its yet heavier counterpoise, to be operated through two levers, one of them working the other by a pin sliding in a slot, as in the Johnson patent?

X-int. 41. Assuming an operative signal to have been constructed in accordance with the description contained in Johnson's patent; that is to say, a signal which is exhibited by the action of one electro-magnet, and reversed or concealed by the action of another electro-magnet, would it, in your opinion, require any invention, as distinguished from the knowledge which should be possessed by a person skilled in the art, to place such signal in the combination of the circuits described in the complainant's patent?

A. If by "operative," in your question, you mean operative in practice on a railroad, then I should say that it would not require invention to combine just such an apparatus as this, or its mechanical equivalent, with the circuits, etc., described in complainant's patent, but that it would involve invention to provide a signal exhibited by the action of one electro-magnet and removed or concealed by the action of another, which was not identical with this apparatus, or its mechanical equivalent, and to combine the same with
408 the circuits, etc., referred to in complainant's patent. Moreover, it is not to be forgotten that the successful operation of said device is simply an assumption, and if not proved by previous use, would have required *experiments*, even if, after such experiment, it should be found to operate successfully.

X-int. 42. In your answer to your own question under the second head of your answer to the 8th int., referring to the non-insulation of the rails from the earth—"I am convinced that this difficulty alone would be fatal to the carrying out of the plan proposed in the patent," are you familiar with the practical results of any experiments which have been made with railroad tracks not insulated from the earth, or is your answer founded merely upon your theoretical opinion of the *probable* result of such non-insulation.

A. My opinion is founded chiefly on theoretical considerations, and upon my general knowledge of the difficulties presented by loss of insulation in similar apparatus, such as bell signals carried through buildings, and recording chronographs, such as I used in connection with the photographic observation of the eclipse of 1869, where I used a system of self-recording signals between the various instruments and observers.

I have also heard, as a matter of report, that these systems, involving the insulation of portions of track, have not met with practical success; and among all the numerous devices involving this feature, which are described in the literature of the subject, I do not remember any in which any record of a practically successful application is contained.

X-int. 43. Please examine the patent I now hand you, No. 129,425, granted to F. L. Pope, dated July 16th, 1872, and marked Complainants' Exhibit O, especially the second column of the
409 second page, and also English patent to Wm. Rob't Lake, No. 2461, dated August 19th, 1872, and which is put in and marked Exhibit P, and say whether or not in your opinion a sufficient description is therein given of a method or means of insulating from each other the abutting ends of two adjacent rails in a railroad track which, taken in connection with the accompanying drawings, would enable a person skilled in the art to effect the desired result?

(Defendants' counsel objects to the question, as irrelevant and immaterial, and also objects, on the same grounds, to the introduction by complainants of Exhibits M, N, O, and P.)

A. The description is quite sufficient to enable any one skilled in the art to do the thing described, but I do not believe that when this was done it would produce the desired effect, if by that you mean the production of a successful, permanent insulation; the wear of rails on a railroad consists largely in the carrying off of minute fragments of iron from the rails; if the insulating material were such as wood or any softer substance, these would imbed themselves in it, and soon form an electric connection or conductor. If the material vulcanite were used, as proposed, this would, when exposed to light, rapidly lose its insulating property on the surface, and especially in wet weather would become a good conductor. The film of water which, during wet weather, would naturally cover every part of the track, would also form a good conductor between adjacent rails, and though of course this mode of insulation would work for a time, and under favorable conditions, it could not be relied upon under the conditions of practical use.

410 (The complainants' counsel objects to all the answer after the word "described," as irresponsive.)

X-int. 44. In your opinion would any especial insulation be required in practice other than that which would be necessarily afforded by the wooden sleepers or ties, upon which the rails of a railroad ordinarily rest, in order to sufficiently insulate from the earth the short sections of rail that constitute the circuit-closers in complainants' patent, so as to enable an electric signal to be operated thereby?

A. If, by enabling an electric signal to be operated thereby, you mean enabling an electric signal to be operated occasionally when the ground and sleepers were dry, as during a drought in summer, and not to operate during wet weather, or when the ground and

sleepers were damp, then undoubtedly no other insulation than that afforded by the dry ground and dry wood would be necessary.

X-int. 45. Were there not known and in public use, or patented or described in printed publications prior to the date of complainants' patent, many devices adapted to be placed along the line of a railroad, and capable of being put in action to close an electric circuit by the contact therewith of a moving locomotive or train, which devices did not depend upon insulation of the track, or any portion thereof?

A. Many such devices were known, patented, and described in printed publications prior to the date of complainants' patent, but I know of none that were in public use or successful operation, except those which were devised, and I believe patented, by Thomas S. Hall, or those associated with him.

411 X-int. 46. Referring to the last clause of your answer, int. 10, in which you say "in the second place, etc.," will you please give your reasons for the opinion you therein express?

A. The simplest way of equalizing the resistances under the conditions involved in the system suggested in complainants' patent would be to provide a set of resistance coils for each station, except the last, and to have these adjusted from time to time by a skillful electrician whenever any change was made in the length of the line, number of signals or the like. These resistance coils are, as I believe, very expensive pieces of apparatus, and if used to control powerful currents, would be liable to get out of order and to suffer variation. It is for these reasons that I consider the necessity of thus equalizing the resistances of the various circuits involved in this system would involve trouble and expense, and a liability to derangement, which would constitute a serious practical objection to this plan.

Adjourned to January 14th, 1879, at 11 o'clock a. m.

NEW YORK, *Jan. 14th*, 1879.

Present: Mr. Chamberlin, for complainants, and Messrs. Baldwin & Van Santvoord, for defendants.

Cross-examination of Prof. HENRY MORTON continued:

X-int. 47. In the second line on the fourth page of complainants' evidence the complainants' witness says: "At a point perhaps a mile distant another signal was arranged in precisely the same manner, in connection with a second circuit-closer, and the same positive and negative conductors."

412 Also in thirteenth and fourteenth lines of same page, the same witness says: "I examined two of these signals and saw many others along the line of the road." Taken in connection with the description which precedes it, and the drawing, Exhibit C, does not this necessarily imply that the system therein described embraced two or more electro-magnets for actuating the signals, and two or more electro-magnets for releasing the signals in combination with one and the same pair of line wires and one and the same battery?

(Counsel for def'ts objects to the question as incompetent.)

A. As I said in my previous answer to int. 11, "admitting that this" (that is, the omission from the drawing of any indication or reference to more than one circuit-closer, and electro-magnet for displaying a signal and one circuit-closer for reversing or concealing the same) "is an oversight, and that the drawing might be further continued or duplicated so as to introduce another station with its pair of magnets," it would then correspond, as so amended or added to, with the verbal description in your question beginning with the words two or more "electro-magnets," and continuing to the end of the question.

The drawing so corrected or amended would then correspond with the passages you have quoted from compl'ts' testimony, but would not correspond with the earlier statement of the same witness, when on page three, line 6, he says: "I have made a diagram which exhibits the apparatus I have examined or so much of it as is material to this case, which I annex, and which is marked Exhibit C."

413 To avoid misunderstanding, I think it right to point out here again that the drawing so amended, while conforming to the verbal description already noticed in your question, would not correspond to the corresponding portion of complainants' patent.

(Last clause of answer objected to by complainants' counsel as irresponsive.)

X-int. 48. Referring to the system of circuits, signal and circuit-closers shown in Complainants' Exhibit C, would it, in your opinion, make any substantial difference in the principle of its operation or in the results obtained if a metallic conductor, insulated from the earth in the same manner as the conductors of C and Z, were substituted for that portion of the circuit which is formed by the earth, as shown in the diagram I now hand you, which complainants place in evidence, and which is marked Exhibit Q?

A. The system represented in this exhibit, which would then consist of three line wires, two positive, or conveying the current from the battery to the other end of the line, and one negative carrying it back to the battery from the further end of the line, would then differ from that represented in Exhibit C only in the circumstance that the current, after reaching the end of the line, instead of flowing freely into the earth without experiencing any resistance whatever in so doing, would have to pass back to the battery through this new conductor, indicated by the full red line on Exhibit Q, in which it would experience whatever resistance was due to that conductor.

Assuming, as would undoubtedly be the case, that all these line wires were of the same material, this would amount to exactly doubling the resistance of the system which on a long line

414 would be a very serious drawback, requiring, for example, a large increase in battery power needed to work the system.

The two positive conductors are these indicated by the two letters

C and Z, drawn in black ink, the negative or return conductor being drawn in red ink.

The words negative conductor, written upon the line Z, I regard as an erroneous designation.

(Defendants' counsel objects to the answer, as entirely irresponsive.)

X-int. 49. Having omitted the material proviso which I had appended to X-int. 48, and which was not given to the examiner to be copied from my paper, I now repeat the question, with that proviso, as follows: Referring to the system of circuits, signals, and circuit-closers shown in Complainants' Exhibit C, would it, in your opinion, make any substantial difference in the principle of its operation, or in the results obtained, if a metallic conductor, insulated from the earth in the same manner as the conductors C and Z, were substituted for that portion of the circuit which is formed by the earth, as shown in diagram, Exhibit Q, provided a sufficient number of elements were added to the battery to enable it to actuate the signals through the additional resistance which would be caused by the substitution of a metallic conductor?

A. If by the introduction of what is described in this "material proviso" the corresponding difference (material and substantial, in the practical working of the system, and yet excluded by this proviso from consideration) is assumed, I think there will be no material difference in the practical operation of the apparatus.

415 Theoretically there would be a great difference, which I think I can make plain by a simple illustration.

Suppose we had a pump drawing and forcing water, and in the first instance connected the inlet of this pump with the East river, and the outlet of this pump with a long pipe stretching across to the North river, where it terminated in a closed end.

Suppose, again, that parallel with this long pipe we had another opening into the North river, but closed at the end nearest the pump or East river, and that between these two pipes at various points were connecting tubes controlled by stop-cocks or valves. If all these valves were closed the pump could force no water through the tube or tubes, but if any valve were open then water would run from the pump through the first tube to that valve, through this valve into the second tube, and through it into the North river.

The outflow from the end of the tube into the North river would be practically unobstructed by any raising of the level of said river produced by said outflow, nor would the level of the East river be so lowered as to increase the labor of pumping water from it by the amount withdrawn; and though we might say, in a certain sense, that when pumping water out of the East river and pouring it into the North river we were establishing a circuit completed through the bay and ocean, yet it would be much more exact to regard this action as a pumping out of one vast reservoir into another, or, better yet, from one part of a universally extended reservoir into another.

Now, we might modify this supposed experiment by carry-

416 ing a third pipe from the end of the second, which before

discharged into the North river, back to the pump, and connecting it with the inlet of the pump, which would then be disconnected from the East river. If the pump were then worked with one of the valves between the first and second pipes open as before, the water would then flow part of the way through the first pipe and the rest of the way through the second to the North river end, and then come back by the third pipe to the pump again, so forming a true circuit, with all that the same involved as regards the dependence of one part upon the other.

Now, these two methods of pumping from river to river without a return circuit properly so considered, and with one, would, in many respects, be practically alike, and in some different, and their resemblances and differences would be precisely such as I find between the two plans indicated in Exhibits C and Q, in the first of which the electric current is taken from the earth at one end of the line and thrown into it again at the other, and by the other of which it is simply moved through a continuous circuit of wire.

(The compl'ts' counsel object to that portion of the answer including and subsequent to the word "theoretically.")

X-int. 50. Would it make any practical difference whatever in the operation of the system shown in Exhibit C, provided the metallic conductor which is substituted for the earth in Exhibit Q, offered no greater resistance to the flow of the current than does the earth?

A. Not in the operation of the system, only in the cost of establishing it.

X-int. 51. In a system of circuits similar to that shown in
417 Exhibit C, but having a metallic conductor insulated from the earth instead of the earth itself as a portion the circuit, as shown in Exhibit Q, if all the circuit-closers were in their normal condition, that is, open, would not the conductor C be charged with positive and the wire Z with negative electricity?

A. They would, in the arrangement shown in Exhibit Q, but not in that shown in Exhibit C.

X-int. 52. Is there any impropriety, then, in designating C as the positive and Z as the negative conductors, in such a system of circuits as that represented by the Exhibit C?

A. Yes; a very manifest one, as far as the conductor Z is concerned, which, in the arrangement exhibited in this Exhibit C, is not charged with negative electricity. Moreover, the propriety of using the term positive or negative conductor does not depend, as I conceive, upon the question whether when no electricity is flowing through said conductor, and it is therefore not performing its function as a conductor, it may contain an inappreciable charge of positive or negative electricity, but whether, when it is acting as a conductor, the large volume of moving electricity, which constitutes the efficient current, moves through it in the direction it would follow were said wire connected with the positive or negative pole of a battery.

Now, both in Exhibit C and in Exhibit Q both the wire C and

the wire Z convey the current in the same direction; therefore, if one of them is properly a positive conductor, so is the other.

The red line in Exhibit Q is the only one in which the current moves in the opposite direction, and therefore the only wire that can be properly called a negative conductor.

418 X-int. 53. Does not the same difference in the electrical condition of the conductors C and Z, by virtue of which a current flows from one to the other through any one of the subsidiary conductors, when closed, exist whether the earth forms a part of one of the conductors or not, except as to the degree of said difference?

A. In one sense, yes, and in another, no, and this distinction, I think, I can make plain by reference to my former illustration of the pumps and pipes.

In the first supposed case, when the second pipe simply opened in the North river, previous to opening any one of the valves between pipes one and two, there would be a pressure on the valve from pipe one, and neither pressure or suction on the other side of said valve.

In the second case, when the return pipe was used, previous to the opening of any valve, there would be pressure on one side and suction on the other.

Now this suction or relief of the normal pressure may be described mathematically as negative pressure—that is, the same mathematical quantity as the pressure only affected with the negative sign (—). Looking at it, therefore, in a mathematical light, we might say that this was simply a difference of degree, as a quantity affected with a minus sign on one side of an equation can, of course, be transferred to the other side by changing its sign to plus.

In the same sense we may say that the same difference in condition between the pipes one and two at the point of communication would exist in the two supposed cases, and that the same difference of electric condition between the two points of the conductors where contact was to be established would exist in the two plans shown in Exhibits C and Q, except as to the degree of said difference, and yet there would be decided points of dissimilarity in the two cases.

419 X-int. 54. In the arrangement described in the patent of Bianchi (Exhibit 42), does not each and every one of the circuit-breakers along the line of the railroad when acted upon by a moving train actuate not merely one, but simultaneously all the automatic signals along the line of a railroad?

A. It does.

X-int. 55. In the arrangement described in complainants' patent, Exhibit A, does not each and every one of the circuit-closers along the line of a railroad when acted upon by a moving train set in action, or exhibit, the particular signal placed at a particular point upon the railroad, which is connected therewith by a branch or subsidiary circuit and no other?

A. It proposes so to do, and if it should operate successfully would so do; I should have made the same qualification in regard to the Bianchi patent.

X-int. 56. Is not then the arrangement and the result proposed by Pope, materially different in that respect from that proposed by Bianchi?

A. The result is materially different in this respect, and in so far as the arrangement effects this result it is also materially different.

X-int. 57. Is not the result contemplated by the action of the combination set forth in the first claim of complainants' patent, as described in the specification, the successive exhibition of a series of signals along the line of a railroad, each one being exhibited automatically by the action of the train as it passes it?

A. It is.

X-int. 58. Please say whether or not you find in British patent of Clark (Exhibit 44) all the elements of the combinations
420 claimed in the first, second, or third claim, or either of them, of complainants' patent?

A. I do not find the combinations constituting either one of the three claims specified.

X-int. 59. Referring to your answer to the int. 57, will you please say whether or not, in your opinion, the result therein referred to can be produced by any modification of the apparatus described in the English patent of Imray (Defendants' Exhibit No. 45), which would not require the exercise of invention, in your opinion?

A. I should think that the result referred to in my answer might be produced by the means indicated by Imray without further invention, but whether they would work successfully could, I think, only be determined by experiment.

X-int. 60. In the last clause of your answer to int. 22, you say: "It was only when experience had demonstrated that a battery strong enough to operate the most distant magnet, and therefore, through the highest resistance, would destroy the connections of the circuit-closers, that this practical difficulty would become manifest."

Assuming the existence of a signal mechanism operated by an electro-magnet or magnets (such for example as Defendants' Exhibit No. 16), would not any competent electrician, knowing the amount of battery power required to operate such signal on a short circuit, be able to determine with sufficient accuracy for practical purposes the amount of battery power required to produce the same effect in a circuit of say ten miles of line wire of known resistance without actual trial?

A. He could.

X-int. 61. Assuming the amount of battery, however, required to operate the most distant signal to have been thus deter-
421 mined, ought not a competent electrician to be able to predict what the effect of such power would be, when employed to operate a similar signal apparatus and its circuit-closer when the resistance of the ten miles of wire was removed from the circuit?

A. If his attention were drawn to it, it is quite probable that he might have anticipated or predicted the difficulty; but this is exactly one of those sort of things which competent men in any subject frequently overlook when experimenting in new directions.

X-int. 62. Please examine the book I now hand you, entitled

"Modern Practice of the Electric Telegraph, by Frank L. Pope," and say whether or not the diagram on page 55, sec. 83, of said book does not purport to represent a number of telegraphic sounders or instruments placed in subsidiary circuits between two conductors connected respectively with the positive and negative poles of a battery, and if the arrangement therein shown for equalizing the resistance of the several subsidiary circuits and the effective strength of the currents traversing the same is substantially the same as that shown in Exhibit Q.

A. The arrangement of connections is substantially the same as that shown in Exhibit Q, but I do not find in it, or in Exhibit Q, any arrangement shown for the equalizing of the resistance of the circuits; if the circuits are not equal to begin with, which I should assume them to be, no means whatever is indicated for rendering them so.

(Complainant puts in sec. 83, referred to above, which is marked Complainants' Exhibit R.)

422 X-int. 63. Is not the equality of the resistances of the subsidiary circuits the necessary result of the arrangement shown, assuming both the instruments and wires to be of uniform resistances?

A. It is.

X-int. 64. In your answer to X-int. 22, referring to a system of circuits in which two or more subsidiary circuits are so arranged as to derive their current from a single battery, you say that "it would not involve invention to equalize the unequal resistances of the various circuits which would exist in such a system by any of the well-known means, such as resistance-coils, and the like;" and in your answer to X-int. 23, you say, referring to Exhibits Nos. 5 and 6, "I consider that it would involve invention to so change the system of connections therein as to render all the circuits equal in length, and of equal resistance; this did not involve the simple introduction of a well-known means for producing the effect for which that means had constantly been employed, but involved a radical change in the entire system of connections employed in carrying out the invention, and was really a problem which, when first presented, would seem to offer very great difficulties." You have also stated in your answer to a later question that the arrangements of the circuits shown in Pope's book, page 55, section 83, was substantially the same as that referred to in your answer to X-int. 23. Will you please state why, in your opinion, it did not involve invention to apply one known means for rendering the resistances of the several subsidiary circuits equal, and did involve invention to apply another equally known means for accomplishing precisely the same result?

Adjourned to January 15, 1879, 2 a. m.

423 NEW YORK, *January* 15, 1879—2 *p. m.*

Present: Counsel as heretofore.

Cross-examination of Prof. HENRY MORTON continued:

A. In answering your question, let me point out that I have not said that the arrangement of circuit shown in Mr. Pope's book, page 55, section 83, was substantially the same as that referred to in my answer to X-int. 23, but only that it was substantially the same as the arrangement shown in Complainants' Exhibit Q, and resembled that shown in Complainants' Exhibit C, in so far as the production of circuits of equal resistance was concerned.

Setting this aside, however, as not material to the point about which I understand that you wish to enquire, I will explain why, in my opinion, it did not involve invention to use resistance-coils to equalize the various resistances of the several circuits involved in Mr. Pope's system, as shown in his patent, and did involve invention to so modify a system otherwise like his in this respect, as to have no circuits of unequal resistance in it; all this in view of the extract from Mr. Pope's book, and all that I have said about it.

In the first place resistance-coils and their uses are described in every text-book on electricity, and in every practical treatise on the art of applying electricity to railway signals, as, for example, in the works of De Castro, of Du Mousel, and of Schellen, all of which devote especial attention to this subject.

Their use must therefore without question have been familiar to every one acquainted with the art of applying electricity to the working of automatic railway signals.

424 On the other hand, the plan described by Mr. Pope in his book is not found in any text-books of electricity, so far as I know, nor in any of the special works on the applications of electricity to railroads, to which I have referred, or even in Langdon's work on "The Application of Electricity to Railway Working," London, 1877.

It was, therefore, in no respect "an equally known means" of doing anything, as compared with resistance-coils, and, indeed, did not, as I think, constitute a part of the art of applying electricity to the working of automatic railway signals.

Moreover, in the very arrangement of circuits shown in Mr. Pope's book, it does not appear that the equality in resistance of the connecting wires was any part of the object aimed at in said arrangement, but was simply an accident, the equality sought being that of the instruments, as appears from the language of the description in section 83, where Mr. Pope says: "Every sounder in the combination should have the same size and amount of wire in its coils, as nearly as possible, in order to secure the best results." The omission of any reference whatever to the equality of the connections is very important.

It is also manifest that where the various instruments to be connected by this plan are, as is here shown and described, close together in the same office, the resistances of the wires constituting the circuits would be too small in relation to those of the instruments to be of any account, or to make their equality of any importance or practical effect.

Thus, this accidental and unobserved condition, not developed to an effective degree, would not, as it seems to me, constitute a prior use, invalidating the novelty and invention of the employ-
425 ment of a plan comprising this arrangement on a practical and efficient scale.

As a parallel case, to illustrate my meaning, I would mention a patent for the use of wire rope, covered with gutta-percha, for harness, which, in a recent suit in which I was examined, was brought forward as anticipating the employment of gutta-percha for insulating submarine cables. The harness was in fact a metallic conductor, covered with an insulating coating of gutta-percha, but his honor, Judge Blatchford, decided, as I am informed, that it was not relevant to the case.

(Complainants' counsel object to the clauses beginning with "thus" and ending with "case," at end of third clause.)

Had it been an easy matter without invention, or even with considerable ability in that direction, to introduce this plan of making circuits of equal resistance into his system of electric signals, I cannot imagine how Mr. Pope should have failed to adopt it in place of the very much less efficient and economical plan of producing circuits of unequal resistance, and then equalizing them by introducing resistances, which his patent describes.

That the plan adopted by Mr. Hall to render the various circuits of his system did not involve the use of what was well known in the art of applying electricity to automatic railway signals, appears also from the fact that Mr. Hall himself, who had devoted many years to the development of this very art, and is the only one who has carried it successfully into practical operation, only adopted this arrangement after making many unsuccessful trials without it, and that a patent for the same was, after due examination, granted to him and Mr. Snow by the United States Patent Office.

426 X-int. 65. In the last cause of your answer to X-int 25, you say "the only adjustment which could be understood from this statement in connection with the drawing of the patent would evidently be the introduction of resistance coils, or the like, into the unequal circuits there shown, which, as I consider, would be an entirely different thing from such an arrangement of equal circuits, as is described and claimed in defendants' patent 165,570, Defendants' Exhibit No. 40."

Is there anything in the clause in complainant's patent suggesting the equalization of the resistences that necessarily refers to one of these known methods rather than the other?

A. There is when this clause is taken as it should be in connection with the rest of the patent and the drawing accompanying it. Thus, Mr. Pope says, "the respective resistances of the several circuits should be so adjusted that they will be as nearly as possible equal to each other, as a much more perfect action of the apparatus will be secured thereby."

This very language itself suggests that the resistances of the several circuits would be unequal in the first instance, and might even

continue unequal with no other effect than a less perfect action of the apparatus.

If now we turn to the drawing we see that the plan there represented involves, as an absolutely essential part, the production of circuits of unequal resistance.

Such circuits being produced by the arrangement described by the patent could be equalized, or so adjusted as to be equal, by the use of resistance coils, or their equivalent, which were well known devices for producing just such a result.

427 But even admitting, for the sake of argument, what I do not conceive to be true, that the plan adopted by Mr. Hall and shown in his patent, Defendant's Exhibit No. 40, was a known method, it could not be introduced as a means of obtaining circuits of equal resistance without radically modifying the plan shown in complainants' patent and directly violating certain of its prescribed conditions. Thus complainant's patent says, "the conductors C and Z are virtually prolongations of the positive and negative poles of the battery B."

Now, the plan shown in Defendant's Exhibit 40 excludes the use of any conductors in any way analogous or equivalent to the conductor Z as a virtual prolongation of the negative pole of the battery B, but would oblige us to suppress this conductor and eliminate from the combination all its peculiar functions in reference to the various circuits.

Therefore, I consider that even if this were a known method of obtaining circuits of equal resistance, its use is excluded by the phraseology and drawing of complainants' patent.

Adjourned to January 16th, 1879, 11.30 a. m., for redirect-examination of Prof. Morton.

428 NEW YORK, *January* 16, 1879.

Present: Counsel as heretofore.

Re-examination of Prof. HENRY MORTON:

Re-D. 66. Having reference to X-int. 50 and your answer thereto, would it be practicable to supply a metallic conductor, having no more resistance than the earth, in making a system of electric signals along the line of a railroad, and would a system involving such a return wire be practically the same as one involving connection with the earth at either end?

A. It would not; the resistance of the earth (if we express the fact in that way), is immeasurably small, or practically nothing, in such a case as you mention, and it would evidently be impossible to make a metallic conductor to fulfil these conditions theoretically, or even practically, within the necessary limitations of cost. Thus a copper rod an inch in diameter and a mile long would have a resistance of .05 of an ohm, or one equal to about 25 feet of the best line wire used in practice. Such a conductor as this, though by no means fulfilling the condition of no appreciable resistance, would cost about $3,600 per mile. If the line were 10 miles long, this resistance would be increased ten times, unless the wire were made

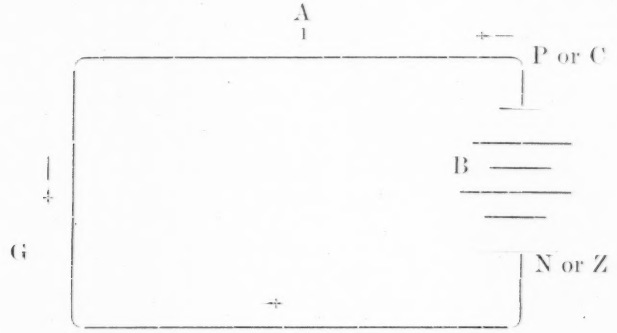
ten times heavier, when it would cost $36,000 per mile, or $360,000 for the 10 miles.

Moreover, the two cases of a circuit through a return wire, and the connection of the line (including the battery, of course,) at either end with the earth, are essentially different.

This I will endeavor to explain as briefly as possible. A galvanic battery is essentially an apparatus for separating and giving
429 motion in opposite direction to what we call the positive and negative electric fluids. For convenience in general discussion we omit mention of the negative electric fluid, or assume it to be represented by the absence of the positive fluid, and confine our attention to the positive fluid, knowing that the action of the negative fluid can always be followed out by following the same course as described for the positive, only going in the opposite direction.

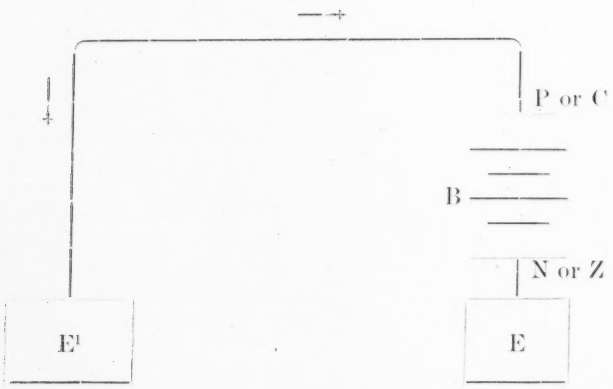
A galvanic battery may then be well compared to a steam-pump, in which the material consumed in the battery, like the fuel burned under the boiler, supplies the energy for driving the positive fluid in a certain direction (and the negative also, if we include it in our description) in the other.

Thus a battery with a continuous metallic circuit would be shown as follows: (See Figure 1.)



The positive fluid, set in motion by the battery B, will flow round in the direction of the arrows, expending the energy it gets from the battery against the resistance of the wire by developing heat in the same. If the wire were divided at any point A, the current would cease to flow, the battery would cease to act and to develop energy,
but would only maintain a feeble charge of positive electric-
430 ity in the part of the wire between the division at A and the positive pole, and a feeble negative charge in the part of the wire connected with the negative pole.

On the other hand, a battery in connection with the earth on one side, and a line wire, terminating in the earth, at it its other end, would be, in the condition shown in Fig. 2:



Here the battery B would separate the positive and negative fluids, and propel the positive fluid in the direction shown by the arrows, until it passed into the earth at E¹, where it would escape freely, like water flowing from the open end of a pipe. Fresh positive electricity would be drawn as required, from the earth, at E, and thus, as regards the circuit, from P to E¹, there would be no practical difference in the general action of the flowing current. There would, however, be very great and essential difference if we consider the entire working of the whole system.

As in many cases, these differences are not taken into account, it is very common to speak of the "circuit completed through the earth," but every one using this expression knows that it is
431 simply conventional, like the phrase rising or setting of the sun.

To point out some of the differences of the systems, I would say:

1st. In the closed-circuit system, shown in Fig. 1, the energy developed in the battery must not only carry the positive fluid from P to G, but must also force it through the resistance of the return wire from G to N. In the system shown in Fig. 2, the energy developed in the battery is only obliged to force the positive fluid from P to E¹, and does not need to expend any power in bringing it back to N. This, in practice, would save about half the battery power used in working the system.

2d. In consequence of the less amount of battery power needed in the second system, the tension or tendency to escape or leak along the line would be reduced proportionately, which would render the insulation of the line easier to secure and less liable to failure.

In consequence of all this, while it is quite true that it would make no practical difference in the operation of the system shown in Exhibit C (which, be it remembered, only shows a short line or

single "block"), if a wire of no appreciable resistance were used in place of the earth connections, except in the great cost of such a conducting wire, yet, in a complete practical system, such as is contemplated in the patent of complainant, or in the systems actually put in operation by the defendant, there would be decided and important practical differences, as I have above shown.

Re-D. 67. What recent suit do you refer to in your answer to X-int. 64, where the use of gutta-percha, as an insulator, was involved?

432 A. The case of Clinton G. Colgate *versus* The Western Union Telegraph Company, and the exclusion of the harness matter came up in the course of the argument, as I was informed by Mr. Frederick H. Betts, of counsel for complainant.

(Complainant's counsel adds his previous objection, that the foregoing statement is only hearsay.)

(Counsel for defendants offers in evidence an article, entitled "Electric Signal Apparatus for Railroads," signed Geo. B. Prescott, found on page 109, of No. 9, vol. 3, of the newspaper "Journal of the Telegraph," dated New York, April 1st, 1870, and it is marked "Defendants' Exhibit Prescott.")

HENRY MORTON.

Subscribed and sworn to before me, this 16th day of January, A. D. 1879.

E. E. MARVIN, *Ex'r.*

433 DEFENDANTS' EXHIBIT 1.—E. E. M., *Ex'r.*

[From the American Artizan, March 27, 1872.]

On the Application of Electricity to the Regulation of Railway Traffic.

By F. L. Pope, Electrical Engineer.*

If we consider steam, the almost universal motor, as the muscle of modern mechanism, we may with equal propriety regard electricity as its brain. The want of success which has attended the numerous attempts which have been made during the past thirty years to utilize electricity as a motive power has served to indicate to the more thoughtful class of its inventors that its true function, as applied to machinery, is not that of a prime mover, but rather that of a guiding, controlling, and supervising intelligence, almost rivaling that of the human mind itself. Viewed in respect to this, its manifestly appropriate sphere, the number and variety of its probable and possible applications in the future are almost beyond computation. In fact, the cultivation of this vast field can scarcely be said to have fairly been commenced.

I propose, in this paper, to give some account of the progress which has been made in the development of one of the most im-

* Paper read before the New York Society of Practical Engineering, March 13, 1872.

portant of these applications of electricity—that of the supervision and control of the movements of trains upon railroads.

The peculiar fitness of this mysterious agency for this work is at once apparent upon the most casual consideration of the sub-
434 ject. On a railroad whose trains are moved by telegraphic orders, the official who directs their movements is rendered practically omnipresent. He is virtually everywhere at the same time, and he can make his arrangements and carry them out with as much certainty as if every train were within the reach of his vision and within sound of his voice as he sits at his desk.

The first railroad in this country which provided itself with a telegraph line devoted exclusively to the business of the road was the New York & Erie. A single wire was put up about the year 1850, between Piermont and Dunkirk, which was at first employed merely for the transmission of communications to and from officers, employees, etc. Ordinary public business was also transacted to some extent, as opportunity afforded. The idea of its being practicable or safe to employ the telegraph for the movement of trains does not seem to have originally occurred to any of the officers of the road. Upon one occasion, some time during the year 1851, Mr. Luther G. Tillotson, who was then superintendent of the telegraph line, together with the division superintendent of the railroad, were in the telegraph office at the depot in Elmira. The express train from New York, though due, was known by means of telegraph to be about four hours late, and certainly not within a hundred miles of Elmira. An eastward-bound stock train lay on a siding at Corning, eighteen miles west, waiting for the express to pass. A westward-bound freight train at Elmira was also waiting for the express. It was no uncommon occurrence for freight trains to be held in this way for hours and even days by belated passenger trains. In fact, it is vouched for as an actual occurrence that a third-class
435 train on the Erie road once lay on a siding at Union station for a whole week before it could get away according to the rules. On the occasion in question, it occurred to Mr. Tillotson that the stock train might be ordered to Elmira, and the freight sent forward to Corning, thus saving thirty-six miles of running time, and the whole operation be completed long before the arrival of the express. But this idea was so utterly without precedent that the superintendent could not at first be prevailed on to give the order, even when Mr. Tillotson urged that there could be no possible danger, even if the express *did* arrive in the meantime, as it could be detained at Elmira until the arrival of the stock train. Finally it was determined that the superintendent should detain the express at Elmira, in case it unexpectedly appeared, and also order the freight to go ahead as far as Corning. Mr. Tillotson accompanied the freight train, armed with a written order from the superintendent to bring back the stock train, which was accomplished without difficulty long before the arrival of the express.

The success of this experiment was encouraging, and led to the next step, that of transmitting the orders by telegraph to the conductors of the trains. After this had been done a few times with-

out accident, Mr. Tillotson suggested, as a further precaution, that each conductor receiving an order for the movement of his train should telegraph back his understanding of the order before being allowed to execute it, which was accordingly established as a rule. This was the origin of the American system of train dispatching, which was first adopted on the Susquehanna Division of the Erie railroad, and soon after on the entire line. The credit of its general adoption upon the Erie road is due to the late Charles Minot, who was then general superintendent. To those familiar with
436 the history of such improvements, it is almost superfluous to state that the most strenuous efforts were made to prevent its introduction, not only by nearly all the other officers of the road, but by the conductors and engineers, some of whom went so far as to sacrifice their situations rather than to submit to such an innovation as that of running against the time of another train on telegraphic orders. The trepidation and alarm manifested by some of these conservative gentlemen upon the general adoption of the system was a source of infinite amusement to the telegraphic operators.

In his report to the stockholders, made in 1855, after the system had been in use for four years, the general superintendent referred to it as follows:

"A single-track railroad may be rendered more safe and efficient by a proper use of the telegraph than a double-track railroad without its aid, as the double track can only obviate collisions which occur between trains moving in opposite directions, while the telegraph may be effectually used in preventing them either from trains moving in an opposite or in the same direction.

"I have no hesitation in asserting that the single-track railroad, having judiciously located turn-outs equal in the aggregate to one-quarter of its entire length, and a well-conducted telegraph, will prove to be a more safe and profitable investment than a much larger sum expended on a continuous double track operated without a telegraph.

"In moving trains by telegraph, *nothing is left to chance*. Orders are communicated to the conductors and engineers of the opposing trains, and their answers returned, giving their understanding of the order before either is allowed to proceed.

"It would occupy too much space to allude to all the practical purposes to which the telegraph is applied in working the
437 road, and it may suffice to say that without it the business could not be conducted with anything like the same degree of economy, safety, regularity, or dispatch."

The system, having once become thoroughly established upon the Erie road, gradually extended itself westward upon the principal through routes, so that at the present day there are few railroads west of New York of any importance which are not operated in this way. Singularly enough, the notorious conservatism of the New England railroad managers has thus far prevented any of them from employing the system at all, with the single exception, I believe, of the Vermont Central road. A vast amount of money

might have been saved, in some instances, which has been needlessly expended in the construction of a second track through a mountainous and difficult country many years before it would have become a necessity, had a proper system of controlling the trains by telegraph been introduced.

The general principle on which trains are moved by telegraphic orders on all single-track roads is the same, although, as might naturally be expected, considerable diversity exists in regard to the details. It consists, primarily, in concentrating the entire responsibility, as far as practicable, in the hands of one person, who is officially known as the train dispatcher. Through the agency of the telegraph, the train dispatcher, as I before remarked, becomes virtually omnipresent. No irregular engine or train is permitted to move upon the road without his knowledge and his direction, and every train, whether regular or otherwise, is at all times subject to his orders. His authority is absolute, and his instructions must be obeyed fully and to the very letter. He is required to have a thor-
438 ough knowledge of the rules of the road and their practical working. He must be familiar with the character of the road itself, the location of its grades, the location and capacity of sidings and passing places, the power of the different locomotives, and all the apparently endless details of its operation, in order that he may issue his orders intelligently when an emergency arises. The dispatcher is in all cases an expert telegraphic operator, and during the hours he is on duty sits at the instrument, personally sending and receiving the telegrams by which the movements of the trains are regulated. He has before him a copy of the printed time schedule of the road, on which the different trains are distinguished by numbers, those going in one direction having even numbers, and those going in the other direction odd numbers. He also has a corresponding blank schedule, properly ruled, called the "train sheet," in which the actual time of the arrival, passing, or departure of every train is set down as reported by the operators at the stations along the line. In all communications relative to the trains, they are invariably referred to by their distinguishing numbers.

Each station along the line is provided with a colored day and night signal for stopping trains, placed in a conspicuous position, so as to be seen by the engineer when approaching from either direction, and capable of being managed by the operator without moving from his instrument.

The movements of the trains are theoretically governed by certain rules printed upon the time schedule. Whenever a train fails to make its schedule time from any cause, then the dispatcher takes it in hand. He arranges the meeting and passing points according to circumstances. The telegraphic order is always issued
439 first to the train having the right of the road, and then to the opposing train. When the proper responses are received the dispatcher replies by a signal signifying "correct," and the trains move forward as directed. If it becomes necessary to stop a through train at some station to await the arrival of an opposing

train, an order is issued to the operator to "Hold No. —." The operator first turns on his signal, and then replies, "No. — is held." When the train in question comes up, the engineer observes the signal, and stops until allowed to go forward by the dispatcher.

The amount of time and money saved to American railroads by the use of this system is almost incalculable. Some idea of the extent to which it is used may be inferred from the fact that there were sent from the dispatcher's office of the Michigan Central railroad at Kalamazoo during the month of January, 1871, more than 16,000 distinct train orders, or on an average of about one order every three minutes, including nights and Sundays!

Three or four years ago a system differing altogether from the one which has just been described was introduced on the line between New York and Philadelphia by Ashbel Welch, chief engineer of the united railroads of New Jersey. This line having a double track the entire distance, the danger more especially to be guarded against was that of collision between trains going in the same direction, and the system under consideration was arranged with particular reference to this fact.

On the New York and Philadelphia route telegraphic signal stations are established at intervals somewhat less than the shortest that are permitted between trains moving in the same direction, averaging, perhaps, two and a half or three miles apart between Jersey City and New Brunswick. South of New Brunswick, where there are fewer trains, the stations are about five miles apart. Each of these stations is provided with a signal, placed where it can be seen as far as possible in both directions. This signal consists of a white board by day and a white light by night, shown through a circular aperture two feet in diameter, in a black signal-box. A partition in the box separates the signals for the opposite directions. The white board or light is ordinarily covered by a red screen. The white or "all-right" signal is exhibited to an approaching train by the operator at the telegraphic instrument pulling a cord. The moment the engine passes he lets go the cord, and the red screen drops by the action of gravity, concealing the white signal.

440

[From the American Artisan, April 3, 1872.]

BY F. L. POPE, ELECTRICAL ENGINEER.*

A special telegraph wire and an operator at each signal station are required by the system described in the earlier portion of this paper. The practical working of it is as follows:

As a train approaches within a quarter of a mile of a signal station the whistle is sounded as a notification to the operator on duty at that point. If he has received word that the preceding train has reached the next station, he pulls the cord showing the white signal, indicating that the line is clear, and the train goes forward. As soon

*Paper read before the New York Society of Practical Engineering, March 13, 1872.

as the last car has passed, and he has seen the red flag or light at the tail of the train, he notifies the last station back that the
441 train has passed. Should he not see a red flag or light on the last car, it would indicate that part of the train had been uncoupled and left on the road, in which case he telegraphs to headquarters for special instructions.

In the absence of information of the arrival of the preceding train at the next station, the operator is not allowed to give the "all-right" signal, and the approaching train is required to stop for explanations or proceed under proper regulations, with the expectation of finding the track obstructed.

In this system, reports of the time of passing of each train are telegraphed from each station to the next adjoining one in either direction, and also by a separate wire to the office at headquarters, where it is recorded on a train sheet, as in the first-mentioned case.

It will be observed that this arrangement, when properly carried out, affords almost absolute safety. No engineer must pass a station until the white signal is shown. No operator must show the white signal until he has received positive information that the whole of the preceding train has passed the next station. Nor must he telegraph back such information to the last station until he has certainly ascertained that the whole of the train has passed. Nothing is left to chance, or to the judgment of the operator or engineer. Two or three plain and simple rules comprise the whole system.

The only objection that can be urged against the general adoption of this system is that of expense. At least two telegraph operators are required at every station to attend the signals day and night, and the stations on some roads would require to be very numerous. This fact has lead to the invention of automatic signals, which are operated directly by the train itself, through the agency of electro-magnetism, requiring no attendance except to see that they are kept in working order.

442 Other applications of these electric signals have been made for railroad purposes besides that just alluded to, and it may be of interest to state briefly some facts in relation to them. A very large number of devices of this kind have been patented in England during the last twenty years, few of which, however, possess any valuable features.

The first American inventor who seems to have turned his attention to this subject was Thomas S. Hall, who patented, in 1867, an electric signal and alarm bell to be used in connection with a switch or draw-bridge. This was so arranged that the displacement of a rail at these points would exhibit a danger signal at a distance of half a mile or more in each direction, while at the same time the bell would ring continually until the track was replaced in its original position, thus certainly attracting the attention of every one employed about the place. This was a good idea, but was wrongly carried out, for by his arrangement a break in the conducting wire or the failure of the battery would render the whole apparatus inoperative, a fact of which no evidence would appear until the moment it was needed. It would obviously be unsafe to depend im-

plicitly upon the indications of a signal which might, under some circumstances, show no sign of danger, even when the switch or draw was displaced. The only alternative was to reverse the plan, so as to keep the electric circuit continuous as long as the track was continuous also, and exhibit the danger signal by the interruption of the current, in which case any failure of the apparatus itself would give a danger signal and call attention to the defect. This plan involves the necessity of keeping the battery in action nearly the whole time, and is, therefore, attended with much trouble and expense in its maintenance.

443 A subsequent inventor, Mr. William Robinson, surmounted this difficulty by a very ingenious arrangement, which was patented in 1870. In his plan, the circuit is kept continuous at the bridge or switch itself as long as the track is in its proper position, but is interrupted at a point a little in advance of the position of the distant signal. When the approaching train reaches the point just mentioned, its wheels press a lever placed near the rail, and the "safety" signal is exhibited to the engineer, unless the circuit is also interrupted at the switch. If this is the case, the signal remains in its normal position, that of "danger," and the engineer governs himself accordingly. The details of this arrangement present some novel features. It will at once be seen that the mere momentary contact of the successive wheels of a rapidly moving train with the circuit-closing lever would not suffice to make an electrical contact of the necessary duration to raise a signal with certainty. Mr. Robinson therefore uses an electro-magnet, so arranged as to keep its own circuit (which is also the signal circuit) closed continuously after contact has once been made, no matter for how brief a period, and this circuit remains thus closed until the train arrives at the switch or draw-bridge, when it presses another lever, breaking the circuit, and the signal is released.

The same inventor, in 1870, took out a patent for a signal and alarm to be placed at highway crossings and arranged on a similar principle. When within a suitable distance of the crossing, the train was made to press on a lever, closing the circuit and elevating a suitable signal, while at the same time an electric bell was rung until the circuit was broken by another lever at or near the crossing. Some of Mr. Robinson's signals, I believe, have

444 been put in practical use on the line of the Philadelphia & Erie railroad.

In 1871 Mr. Hall also brought out a crossing signal, worked by levers in proximity to the rail, but differing in the details of its construction. The result produced was similar to that just referred to. Some of these signals were erected at different road crossings on the Hartford & New Haven, New York & New Haven, and Flushing & North Side railroad.

During the past year Mr. Hall has put in operation a system of automatic electric block signals upon the Harlem railroad, between the Grand Central Depot in this city and Mott Haven junction. This distance is divided into sections of a mile or more in length, and a signal-house is placed between each two sections, the arrangement

being analogous to that already referred to in the New York & Philadelphia line. The normal position of each signal is at "safety." When a train passing over the road reaches one of these signals its wheels press upon a lever, closing an electric circuit and exhibiting the danger signal. By a simple mechanical contrivance the circuit is kept closed and the danger signal is displayed until the train reaches the next signal and operates upon that in the same manner. The movement of the second signal is made to close a separate electric circuit, running back to the one last passed, releasing the latter and allowing it to assume its normal position indicating "safety." A bell is kept constantly ringing in each signal-house as long as the signal remains displayed. This is done by a separate battery brought into action by a relay.

The mode of closing an electric circuit by the passing of a moving train, which has been described in conjunction with the inven-
445 tions of Robinson and Hall, is open to one very serious objection. An express train running at the rate of thirty miles an hour—which is by no means an exceptional rate of speed—moves not less than forty-four feet per second. Imagine the effect upon these levers of from thirty to sixty wheels, each of which is a hammer of many tons, moving at the rate of forty-four feet per second, and this operation repeated perhaps fifty times every day. Any one at all familiar with railroad practices will readily be convinced of the fact that no arrangement of this sort that can be devised will withstand such rough usage for any great length of time.

About a year since, my attention was called to this difficulty of closing the circuit by means of a rapidly moving train, in connection with an improved form of semaphoric signal which had been invented by Mr. S. C. Hendrickson. In seeking to devise some more certain method of accomplishing the desired result, it occurred to me that the rails of the track might in some way be brought into the circuit, so that the connection could be formed by the contact of the wheels of a passing train with an insulated section composed of one or more rails. Several years ago, out of mere curiosity, I had tried the experiment of transmitting electric currents, and, in fact, of telegraphing through the fish-jointed track of the New Jersey railroad between Elizabeth and Rahway, N. J., with entire success. On this occasion, the earth on which the ties were imbedded, as well as the ties themselves, was in a tolerably dry state, and, therefore, afforded a fair degree of insulation, when compared with the great conductivity of the rail, which I roughly calculated to be from 300 to 400 times as great as that of a No. 9 iron wire, such as is ordinarily used in the construction of telegraph lines.

446 In the fall of 1871 I made a practical test of this method of operating a signal at East Cambridge, Mass., on the line of the Boston, Lowell & Nashua railroad. A section of track forty-two feet in length was separated at each end by an insulated joint from the adjacent rails of the continuous track in each direction, and a circuit of wires was formed, which included the battery and electro-magnet for operating the signals, the two ends being attached to the respective opposite rails of the insulated section of track. On

the passage of a train the rails became electrically connected by the metallic wheels and axles of the locomotives and cars, and the signal was thrown into position indicating "danger" to the next following train. The signal was arranged so as to be held in this position by a detent after the train had passed and the circuit was broken. Upon the arrival of the train at the next station it closed a circuit at that point in precisely the same manner, and a current was thereby sent from a battery at that station back to an electro-magnet, which lifted the detent of the first-mentioned signal, which allowed it to resume its normal position of safety.

An experience of nearly five months of actual service in operating an experimental signal upon this principle shows that it is almost absolutely certain in its operation, while it will be apparent upon inspection that, even in the event of its failure to operate, there is no more liability to accident than exists under the present system. The danger signal, once set by a train as it passes the station, cannot be changed to safety except by the arrival of the train at the next station, because the battery current for releasing the signal must come from there, and can only be transmitted by the closing
447 of the circuit by the train itself. If the battery fails, or the wire is interrupted, the signal remains at "danger," and the following train is warned to proceed, if at all, with extreme caution, expecting to meet with obstruction.

If a system of safety signals of this kind can be made at once inexpensive and reliable in its operation, its great value is so apparent as to scarcely need any demonstration. Experience has shown that it is not safe, all things considered, to allow trains to follow each other at the usual rate of speed—say twenty miles or upward per hour—at an interval of less than about seven minutes apart, as in case of an accident or stoppage of a train on the road from any cause it will require as much as seven minutes for a flagman to go back a sufficient distance to warn the following train of the obstruction in season to prevent a collision. It may also be observed that in the confusion attending an accident this precaution is sometimes forgotten, and instances have known where the signal, even when sent back, was not seen by the engineer of the approaching train.

With a proper system of signals, erected at intervals of a mile, it would be possible to run trains at intervals of three minutes apart, with far more safety than they can be run at seven minutes apart under present conditions; for it would be absolutely certain that no train could approach within a mile of another one, provided the signals were observed. The capacity of a road would thus be more than double, at a very insignificant expense, compared with the expedient of laying down a third track, as is now being done by some of the principal roads running out of Boston, and a greater degree of safety would at the same time be assured.

448 The system which has been described would not, of course, supersede any of the precautions now in use, but would serve as an additional security. Its application to tunnels, highway, or grade railway crossings, and other dangerous points, are mere mat-

ters of difference in detail, which need not be dwelt upon at length in this paper.

In concluding my observations upon this subject, I cannot refrain from mentioning the great credit that is due to some of the leading railway companies in the United States for the prominent part they have taken in the introduction of nearly every important improvement in practical telegraphy which has been made during the past ten years. The use of wires of large size and superior strength and conductivity was commenced by Mr. Tubbs, of the Chicago, Burlington & Quincy railroad, many years ago, in the face of strenuous opposition on the part of the officers of the commercial telegraph companies; and the good results were so marked as to lead to its continued use by that company in its subsequent construction. Not until last year did the Western Union Telegraph Company commence to use large wire. The Brooks paraffine insulator, which enables a telegraph line of almost any length to be operated without the slightest difficulty in the most unfavorable weather, has been used for several years with entirely satisfactory results by a dozen or more of the principal railroad companies. The Western Union and other commercial companies still continue to use the old glass insulator of a quarter of a century ago, and the result is a great delay, sometimes a total stoppage of communications during the continuance of every rain storm—an inconvenience quietly submitted to by the public, under the erroneous impression that it is unavoidable. So in the matter of batteries, the commercial telegraph lines still cling to the
449 costly and inconvenient nitric acid combination, apparently for no other reason than because Morse used it on his first line between Baltimore and Washington, while the railroad companies have long since adopted the simple, economical, and effective gravity battery. Other examples of the same nature might be adduced, but enough has been said to show that the managers of the leading American railroads are fully alive to the importance of the employment of that invaluable agent, electricity, in its application to the management and control of their rapidly increasing traffic. A few years will probably witness the general introduction of some system of signalling resembling that which I have endeavored to describe, and which will become an indispensable adjunct to the operations of all roads running a large number of trains in rapid succession over the same track.

EXHIBIT 12.—E. E. M., *Ex'r*, June 6th, 1877.

WEST MERIDEN, CONN., Nov. 15, 1873.

DEAR SIR: In accordance with the notice sent you on the 10th inst., I respectfully invite you to an exhibition of my improved system of Automatic Railway Signals, to be made in Boston on Thursday next, 20th inst., at 11 o'clock a. m., at the new depot of the Boston and Lowell railroad.

Very respectfully, yours,

THOMAS S. HALL.

450 EXHIBIT 13.—E. E. M., *Ex'r*, June 6th, 1877.

EXHIBITION
OF
HALL'S AUTOMATIC ELECTRIC RAILWAY SIGNALS,
At New Depot of the
BOSTON AND LOWELL RAILROAD,
Third floor, front room,
Thursday, November 20th, 11 o'clock a. m.

Admit Bearer.

EXHIBIT 25.—E. E. M., *Ex'r*, June 21, 1877.

[*Envelope.*]

(Postmarked:) Nashua, N. H., Dec. 26.

Chas. H. Mansur,
No. 25 Whitney Ave.,
New Haven, Conn.

[*Letter.*]

GEO. W. DAVIS & CO.,

Manufacturers of the patent automatic cut-off stationery steam engines, portable engines, machinist tools, shafting, pulleys and hangings with self-oiling boxes, and boring machines for boring stationery and locomotive steam cylinders, without moving them from the frame or bed.

451 NASHUA, N. H., *Dec. 26th*, 1872.

FRIEND MANSUR: Your favor of the 23 is rec'd. I was thinking about you a few day ago and wondering where you could be. I am glad to hear you are prospering. Our business is very good. We are making engines and planers.

We do not know that we can sell a 15 H. P. cut-off engine any less than Corliss, but we think our 15 H. P. works better than Corliss.

We will deliver on the cars here an 8 x 24 in. cut-off engine, fly wheel 72 x 12 in., for $1,300. Will furnish a force pump and driving work for $60, and a heater for $40.

This size we call 17 H. P. and is the smallest we make. We can furnish a good second-hand slide valve, 8 x 16 in. engine, in perfect order, for $550—pump and heater same as above.

My family are in usual health.

Miss Celia is not married yet, but the prospect is fair for that event happening some time. I *surpose* you have some children, but you say nothing about them.

Hope you will put your best stock in and have good sound ones, and have them *often*.

Yours, very truly, GEO. A. ROLLINS.

452 EXHIBIT No. 39.—E. E. M., *Ex'r*, *July* 3, 1877.

EASTERN & MAINE CENTRAL RAILROAD LINE, CHARLES F. HATCH, *Gen'l Manager.*

BOSTON, *Nov.* 25, 1873.

THOMAS S. HALL, Esq., *West Meriden, Conn.*

DEAR SIR: I have your favor of the 22d, and have looked over your improved apparatus with Mr. Snow. It appears feasible, and I think well of it. There are some things that I have asked our supr. of telegraph to look over and give me his views of it. Before doing anything further, it seems to me you should deed to us the right to use all your improvements covered by patents. Will you please have that properly done? I am sorry to learn that you are so ill, but hope you are convalescing and will soon be entirely restored to health.

Yours truly, CHAS. F. HATCH.

453 Circuit Court of the United States for the District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL CO.
vs.
THE HALL RAILWAY SIGNAL CO.

Testimony on the part of the defendant, taken before R. E. Stilwell, examiner, under the 69th rule of the Supreme Court of the United States (as amended), for final hearing.

TUESDAY, *June* 19, 1879.

Present: John Van Santvoord, Esq., counsel for defendant; F. Chamberlin, Esq., counsel for complainant.

EDWIN D. MCCRACKEN being called as a witness on the part of the defendant, being duly sworn, deposes and says:

Q. 1. What is your name, age, residence, and occupation?

A. My name is Edward D. McCracken; my age is 41 years; reside at Paterson, New Jersey, and am an inventor.

Q. 2. Are you acquainted with Frank L. Pope?

A. I am.

Q. 3. How long have you been?

A. I think some time in 1869, or the beginning of 1870, that I made his acquaintance.

Q. 4. Had he any knowledge at any time of any invention of yours; and, if so, did you have any commuication with him in regard to it?

454 A. He did. In the fall of 1870 Mr. Pope and I were both exhibitors of telegraph apparatus at the American Institute fair, Mr. Pope exhibiting what is known as Pope and Edison's private-line instrument, and I exhibited my patent alternating batteries. It was called Pope & Edison's printer. While my instrument was on exhibition at the fair Mr. Pope asked me if I had a wood cut of the same, as he would like to publish it in their paper,

the Telegrapher. I think Mr. Pope was assistant editor at the time. I won't state positively, but I am under the impression that he made the drawing of the machine and had a wood cut made for it, and the same publised in the Telegrapher. I had several conversations at the fair of the American Institute with Mr. Pope with regard to the working of his printer, and also with regard to the working of my batteries, and what I claimed for them.

Q. 5. Was any description of your invention published with the wood cut in the Telegrapher?

A. Yes, sir; it occupied the front page.

Q. 6. Do you know who wrote it?

A. I gave Mr. Pope the descriptjon of it.

Q. 7. How often from that time to the present have you met Mr. Pope?

A. Well, I couldn't say whether it was hundreds of times or not, but I met him very often.

Q. 8. Did you ever look, at any time, at the system of batteries on the Harlem road in this city, known as Hall's system?

A. I did.

Q. 9. State when and how you came to do this?

A. I was in the employ of L. G. Tillotson & Co. at the time at No. 5 Dey street, in the city of New York. Mr. Tillotson told me to go up and examine the signal batteries on the Harlem railway, and report to him the condition of the battery for the signal batteries. Tillotson & Co. are a railway and telegraph supply house, and also manufacturers of telegraph instruments, batteries, etc.

Q. 10. Were they in any way employed by the Harlem Railroad Company?

455 A. The relation that existed between the Harlem road and L. G. Tillotson while I was in their employ was, that they bought some of their supplies from our firm. I think Mr. Moore was the purchasing agent.

Q. 11. Were you ever employed by the Harlem Railroad Company to take care in any way of this system of Hall's signal on their road?

A. I was not.

Q. 12. For what purpose were you directed by Mr. Tillotson to look at those signals at the time you have mentioned?

A. For the purpose of seeing why it took so much battery to do the work, and to see whether the batteries were kept in proper working order.

Q. 13. What did you find as the result of your inspection as to these points?

A. I found a large amount of battery, and kept in a filthy condition, and I reported to Mr. Tillotson.

Q. 14. Did you afterwards have any conversation with Mr. Pope in regard to this; if so, state when, and what it was?

A. I did. I called on Mr. Pope at his office, then in Fulton street, I think. I went there to see him because, some time before, I think while their office was in Dey street, Mr. Pope had shown me his signal system. I asked Mr. Pope if a signal system could not be

run with less battery, and how his (Pope's) saytem compared with Mr. Hall's. The reason why I asked this question, as I stated to Mr. Pope at the time, was, because I did not understand either Mr. Hall's or Mr. Pope's system of signals, whereupon Mr. Pope explained to me both the system upon which Mr. Hall and Mr. Pope worked their signals. Mr. Pope then made a drawing of Mr. Hall's apparatus and of his own, and explained both systems to me, stating in substance that it took much less battery power to work his system than that of Mr. Hall. The conversation took place between the 10th day of September, 1872, and the 31st day of January, 1873.

Q. 15. How do you fix the time as being between those dates?

456 A. As I was employed by the firm of L. G. Tillotson & Co., on or about the 10th day of September, 1872, and left their employ on the 31st day of January, 1873, and went to Chatham Four Corners, New York State, on the 1st of February, 1873.

Q. 16. For what purpose did you go to Chatham Four Corners, and how long were you there?

(Objected to, as not in reply to anything put in by the complainants, and that complainants give notice that if claimed by the defendents as properly in the case, complainants will ask leave to put in evidence in reply. Objection applies to interrogations and answers 14 to 16, inclusive.)

A. I went to Chatham Four Corners, I think, on the 2d of February, 1873, for the purpose of trying to bleach wood fibre for the manufacture of paper. I was employed by Mr. Secor in the name of the Columbia Paper Company. I cannot state how long I was there, but the company went into bankruptcy on the 5th of July of the same year.

Q. 17. Did you remain there until they went into bankruptcy or leave previously?

A. My impression is that I did not remain there until the 5th of July. I must have left before they closed. I am certain I was not there on the 5th of July. I might not have been there a month before that time, but cannot say positively.

Q. 18. State more particularly, if you recollect, how Mr. Pope said to you, at this interview you have just mentioned, his signal system used less battety power than Hall's system?

A. I can't remember all that Mr. Pope stated with regard to his system over the Hall system, but it was to the effect that the magnets that moved the armature that moved the levers that set the signals took less electro-motive force than what the Hall system did, the reason being that his magnets were higher resistence than those of Mr. Hall.

Q. 19. Did he state to you anything about the proportion between the battery power that he used and that which Mr. Hall used?

A. He said something with regard to it, but the exact proportion I cannot state.

457 Q. 20. Was anything said at this interview as to a substitution of his system to Hall's system on the Harlem route?

A. There was.

Q. 21. State what.

A. He said that if I could get his system substituted for that of Mr. Hall he (Pope) would pay me well for it, and that I could guarantee it would be run at one-half the expense.

Q. 22. Did you state to him that you came there in behalf of the Harlem railroad, or that you were in the employment of that road for the purpose of taking care of Hall's signals and keeping them in working order?

A. I did not.

Q. 23. Did Mr. Pope know at this time what your employment was?

A. He saw me at Mr. Tillotson's store at work whenever he went in and out. I think I saw Mr. Ashly there as often as once a week all the time I was employed there.

Q. 24. State, as nearly as you can, how long you had been with Tillotson & Co. before this interview with Mr. Pope.

A. It might have been two months, or it may have been a little longer.

Q. 25. Did you see Mr. Pope at any time after this interview in regard to the same matter?

A. I did. I saw him once or twice at his office, and once or twice in L. G. Tillotson's store. I remember once distinctly at L. G. Tillotson's store; he came there to see about some mistake that had been made with regard to kerite wire, and asked me if anything had been done with regard to the Harlem railroad matter. I told him there had not.

Q. 26. What was said between you in regard to those signals at the one or two subsequent interviews at his office?

A. He stated that on one or two, and I can't say but on several, occasions, that the Hall system had failed to give its signal, and that accidents could or would occur with a system that required so much battery force, and went on to state that it only required a slight diminution of battery force to leave the instrument worse than worthless, while with his system that could not occur.

458 Objected to, for reasons given above, and with same notice, objection to apply to all matters not testified to by Pope.

Q. 27. Was anything said at any of the interviews with regard to any difference in the number of cells to a battery in the two systems?

A. There was, but I cannot state the difference in the battery that he said that it took to work his, or the Hall system.

Q. 28. When was the last interview between Mr. Pope and you at which anything was said in regard to the signals on the Harlem road?

A. Some time in December, 1872, or in the early part of January, 1873.

Q. 29. Did you at any of these interviews represent to him that you were in the employ of the Harlem road?

A. I never did.

Q. 30. Did you at any of these interviews represent to him that you had any charge of the Hall signals on that road, or of their working?

A. I did not; for up to that time I never saw neither Mr. Hall or his system.

Q. 31. When did you first become personally acquainted with Mr. Thomas S. Hall?

A. On the 8th day of March, 1879.

Q. 32. Did Mr. Pope, at any of these interviews, state to you that he could save battery power by working a number of signals along the road from one battery only?

A. He did not. As I understood his explanation of his system he made the track his conductor, and the axles of the engine and cars completed his circuit, and that the tracks where the signals were set were insulated, and that he made the track wholly his conductor; that was the way I understood it.

Q. 33. Did Mr. Pope at any of his interviews draw any sketch to show you how a number of signals along the line of a railroad could be worked by a single battery?

A. No, sir.

459 Q. 34. Did he give you, to take with you, any written memoranda descebing his signals, and containing a sketch of the same?

A. He did not give me any written agreement or sketch to take with me, nor have I the slightest recollection of his making any drawing or sketch other than the one made of his and Mr. Hall's instrument, for if he had I should have it now.

Q. 35. Was this sketch which he made of his and Hall's instruments made in pencil or ink?

A. I think that they were made with a pencil on soft paper, for I remember of using a lead pencil on the same paper to have certain explanations made to me by him.

Q. 36. Were the sketches of these two instruments made on the same piece of paper, or different?

A. I think, if my memory serves me right, that that of Mr. Pope's instrument was made upon one piece, and that of Mr. Hall's upon another.

Q. 37. Where were you in the month of April, 1873?

A. I think I was at Chatham Four Corners, New York State.

Q. 38. Did you have any interview with Mr. Pope in New York city on April 10th or April 11th, 1873?

A. I did not see Mr. Pope from the first part of January, 1873, till the fall of the same year.

Q. 39. What was your employment and residence next after leaving the Columbia Mills?

A. I was trying to introduce my patent batteries in the Gold and Stock Telegraph Company. My residence was No. 64 Whitehall street, New York city, I think.

Q. 40. How long did you continue to reside in New York city after this time?

A. I think I remained in New York city till the fall of 1875.

Q. 41. During this time did you meet Mr. Pope; and, if so, how often?

A. I met him occasionally in the streets, and I think once or twice at the American Institute Fair.

460 Q. 42. Have you been divorced from your wife; and if so when, and for what cause?

A. I was divorced from my wife on the 16th day of October, 1875, for the cause of her adultery.

Q. 43. Did you leave her before you applied for a divorce?

A. I did.

Q. 44. Did she know where you went?

A. Yes, sir.

Q. 45. Where did you reside after the fall of 1875?

A. At Alpine, Cloister, and Tenafly, in New Jersey. On the 13th of March, 1877, I went to Chicago; arrived there on the 15th, left Chicago on the 16th; went to Lincoln, Nebraska, left Lincoln in March, 1878; arrived in Chicago, left Chicago August 1st; arrived in New Jersey August 3d, visiting about, but making Paterson my home.

Q. 46. Did you meet Mr. Pope between your leaving New York city, in the fall of 1875, and your going West?

A. I met him repeatedly, casually, but had no conversation; passed the time of day with him and bowed.

Q. 47. Have you met him since your return from the West?

A. I have. I have met Mr. Pope once in the street, and once in the Union Telegraph building. Have been in his office to inquire where Mr. Farmer was staying in the city. Mr. Pope was not in his office at that moment. I inquired of Mr. Prescott, electrician of the Western Union. He sent me to Dickerson & Beman's office. At the time he was testifying in a patent case. I think in March or April, 1879.

Q. 48. How long was it after your return from the West, in 1878, that you first met Mr. Pope?

A. I think it was some time in August or September, 1878, either one month or the other—I can't tell which. I was stopping at the Astor House for a few days with a Mr. E. P. Rice.

Q. 49. When, after your return from the West, did you first meet Mr. Ashley or Mr. Hendrickson, the gentlemen who are now in this room?

A. I don't think that I have spoken ten words to Mr.
461 Ashley since 1873, until to-day, but I have seen him repeatedly on the street. Mr. Hendrickson's face is familiar to me, but I cannot place him.

Q. 50. Was anything said by Mr. Pope to you during any of your interviews in reference to the Harlem railroad matter, as to whether his signal system as he explained it to you was patented or not?

A. Yes, sir. He said that they were secured by letters patent.

Q. 51. Please look at this paper which has just been brought in by Mr. Hendrickson, marked "Exhibit C C," and state whether you ever before saw a paper like this, or of which this is a press copy?

A. I never have.

Cross-examined by Mr. CHAMBERLIN, counsel for complainant:

C. Q. 52. In answer to interrogatory 7, you state that you couldn't say whether it was hundreds of times or not that you met Pope, the complainant. Can you make any more definite estimate than that of the number of times that you so met him?

A. I know and only speak of meeting him in a casual way.

C. Q. 53. Can you state how many times you ever had conversation with Mr. Pope?

A. I cannot exactly; but a great many times. I had a good many conversations with him in regard to his printer. I have had conversations with regard to batteries, but I cannot state how many times these things occurred.

C. Q. 54. When did you last have conversation with Mr. Pope?

A. I don't think that I have conversed with Mr. Pope since January, 1873.

C. Q. 55. When was the last time that you know that Mr. Pope saw you, or that you exchanged greetings in any way with him?

462 A. I don't know that Mr. Pope answered me on the morning on which I spoke to him, in the Western Union building. What I said to him was good morning. I cannot give you the date; I know it was on the day I inquired of Mr. Prescott whether Mr. Farmer was in town or not. I think it was in March. I do not know whether Mr. Pope saw me then.

C. Q. 56. In answer to interogatory 14, you state that you talked with Pope about a signal system, and the question was asked whether it could not be run with less battery, and how his system compared with Hall's. In discussing with Mr. Pope, at the different times you speak of, the matter of signals for the Harlem railroad, was it not always with a view to present a system which would be more economical, reliable, and easily worked than the one then in use?

A. Yes, sir.

C. Q. 57. You state in your direct testimony that at one time Pope made a drawing and showed it to you. Do you know what became of that drawing?

A. I do not.

C. Q. 58 You state in your direct testimony that Mr. Pope proposed to compensate you if you could procure the introduction of his system of signalling, in place of Hall's, on the Harlem railroad. When was that?

A. I think that it was at our first interview, but it may have been at our second. It was sometime in the month of November or December of 1872.

C. Q. 59. What reply did you make to him, if any?

A. I told him that I would do the best I could in the matter to get his signals upon the Harlem road.

C. Q. 60. Can you state any more definitely than you have already done, what improvements were talked about between you and Pope, or what was suggested by him in the way of improvements?

A. I cannot state any.

C. Q. 61. Did you do anything in pursuance of the promise you made to him, and if so, what?

A. I think I told Mr. More that there was a new system
463 which had been invented; that the signals could be worked in a much cheaper and more reliable manner than the Hall system, and that if he, Mr. More, would like to see the same, I should be happy to take him to the office where they were on exhibition. Mr. More made some casual reply, jumped in his wagon, and drove off.

C. Q. 62 Is Mr. More an official of the Harlem railroad?

A. I was led to believe that he was purchasing agent for that road.

C. Q. 63. Did you recommend to any other party connected with the Harlem railroad, as an officer or otherwise, the substitution of Pope's signals for Hall's?

A. I don't know that I ever did.

C. Q. 64. Upon what did you base the recommendation, which you say you made to Mr. More, that Pope's system of signals would be cheaper and more reliable?

A. On the statement of Mr. Pope to me on the amount of electromotive force that it took to work his signals, and also upon the apparatus that he had shown me.

C. Q. 65. When and where did you see the apparatus that you speak of, and what was it?

A. I saw it, I think, the first time, at the office in Dey street; the office of the Telegrapher, I think it was; and at their office in Fulton street.

C. Q. 66. At which place did you see it first?

A. I am quite positive that I saw it at two places; I don't recollect at which I saw it first.

C. Q. 67. When did you see it first?

A. I think I saw it in the fall of 1871; I think that was the first time. I wish to state right here that I am quite positive that I saw what was called Pope's system of signals in two different places; but I am not positive as to Dey street being the first place.

C. Q. 68. Upon further consideration, may it have been in Fulton street that you first saw it?

A. It might have been, but in the first instance it seems that it was in a larger room than it was in the second; yet I may have these two different times somewhat confused; but the conver-
464 sation that took place between Mr. Pope and myself took place in Fulton street, and where I saw the machine.

C. Q. 69. Then if they first had an office in Fulton street in May, 1872, was it in that month or later that you first saw it?

Objected to, as a hypothetical question founded on the supposition of counsel, intending to mislead.

A. My impression is that I saw it before May, 1872, and don't know when they took their office in Fulton street.

C. Q. 70. Can you tell whether the second time you saw it was in their office in Vesey street, instead of their office in Dey street?

A. I have a faint recollection of calling at their office in Vesey

street, and if my memory serves me right, it was some time after this conversation that is referred to herein was made to Mr. Pope.

C. Q. 71. Did you learn from any one at any time since the first of January last that Mr. Pope wanted to see you; and, if so, from whom?

A. I did. I learnt it from Mr. Moses G. Farmer while he was stopping in New York city. I think it was some time in March or April, 1879. Mr. Farmer said that Mr. Pope wanted to see me and wanted my address, and asked me if Paterson was my address, and I stated it was.

C. Q. 72. Have you in any manner since that time communicated with Mr. Pope by letter or otherwise?

A. I have not.

C. Q. 73. Do you know whether Mr. Farmer has communicated with Mr. Pope since that time or not?

A. I do not know that Mr. Farmer has communicated with Mr. Pope.

C. Q. 74. Can you describe the drawing and make a copy of it, which you say Mr. Pope showed you in an interview you had with him?

A. I cannot.

C. Q. 75. Can you do either?

A. No better than what I have already done.

C. Q. 76. Can you tell anything that it contained?

A. In detail, no.

465 C. Q. 77. Can you describe so that a draughtsman can make a copy of it, or any part of it?

A. No better description than that I have already given. I took Mr. Pope's statement as to the mechanical working of the machine, and based my judgment upon his knowledge.

C. Q. 78. Do you mean by that that the drawing made no special impression upon you unaccompanied by what Mr. Pope said?

A. I do not.

C. Q. 79. To what do you refer in the answer just given, that you cannot describe or copy such drawing any further than you have already done it? Please recite what you refer to.

A. That it is impossible for me to draw the circuits, the position in which they stood, when Mr. Pope drew them for me. That he showed me how that Mr. Hall's circuit was completed by the wheels running over a lever, that completed a circuit through a magnet contained in a cast-iron box; he also drew his machine, in which he stated that the circuit was completed through the axle or axles of the locomotive or cars.

C. Q. 80. Do you understand that you have previously stated the matter contained in the answer just made by you?

A. I do not understand the question.

C. Q. 81. I mean, do you understand that you have stated the matter contained in the answer to the 79th cross-interrogatory previously in any answer to any interrogatory or cross-interrogatory put to you to-day in this examination.

A. I must say that I am perfectly at a loss to comprehend that

question. But if it means, have I stated anything, either in direct or cross-examination, with regard to drawings made by Mr. Pope to explain the difference of the working of the two systems, namely, that of Hall and Pope, I would say yes.

EDWIN D. McCRACKEN.

466 WALTER O. LEWIS, called as a witness on the part of the defendant, being duly sworn, deposes and says:

Q. 1. Were you sworn as a witness for complainant?

A. I was.

Q. 2. Please look at the paper I now hand you, and state what it is.

A. It is a letter written by me to William A. Cummings upon the subject of Hall's system of electric signals for railroads. I wrote it, I suppose, at the time it bears date.

Defendants' counsel offers in evidence the letter shown to witness, and it is marked "Defendants' Exhibit Lewis Letter."

Q. 3. Does this letter contain, as you now believe, a correct account of the matters described therein?

A. Yes, sir.

WALTER O. LEWIS.

Subscribed and sworn to before me, this 19th June, 1879.

R. E. STILLWELL, *Examiner.*

NEW YORK, *March* 22, 1870.

WILLIAM A. CUMMINGS, *Pres't, etc.*

DEAR SIR: At your request I visited Stamford, etc., and examined Hall's patents for working a system of signals by electricity, in operation on the N. Y. & N. H. railroad, to indicate a change of a railroad switch, the opening of a draw-bridge, and signalizing the approach of a train of cars at any given point or road crossing, all of which work automatically by the displacement of a switch, the movement of the draw, and by the flanges of the wheels of the cars. The operations differ to meet the several combinations, and require various electrical applications to produce the desired results, all of which are most happily arranged.

When a switch is turned, a signal or disk, or a series of them, about twelve or fifteen inches in diameter, is brought into view, and a bell sufficiently large to be distinctly heard for several rods
467 is set to ringing. This signal will remain in view, and the bell continue to ring so long as the switch remains out of its normal position; hence the engineer on an approaching train of cars can see the signal in time to stop his train before it reaches the misplaced switch, and the bell will notify the switch-tender that his switch is not in a proper position. It is a monitor, constantly at hand to admonish him of his negligence should he forget to replace his switch after opening it.

The same applies to a draw-bridge. Let the draw be almost closed,

so nearly so as that at a little distance the opening could not be discerned, the signal would remain up and the bell would continue to ring, so that the engineer would be informed, and the bridge-tender would be notified that his draw was not in its proper position to carry a train of cars safely over it.

The signalizing the approach of a train of cars at any street or road crossing is, perhaps, the most ingenious and important, as it can be placed at the most out-of-the-way place, where there are no inhabitants, but where a road crossing is dangerous from a curve in the road, or the view obstructed by woods or high embankments. Upon the approach of a train, and when at a given distance the flanges of the wheels pass over a lever, which is graduated so as to require at least two thousand pounds to move it, and which in its functions is the same as the "key" of the Morse telegraph instruments, which closes an electric circuit which raises a signal and rings a bell, which signal remains displayed and the bell continues to ring until the train shall have passed the road crossing, when the flanges of the wheels pass over another similar lever which opens the electric circuit, when the signal falls out of sight and the bell stops ringing, and the machinery is in condition to repeat the same operation on the passing of another train, and so continue indefinitely.

By this same arrangement a road, however long, may be divided into sections of one or two miles, or from station to station, and each train will signalize itself to the farther end when it enters a section, and replace the signals when it passes out, so that collisions, with any degree of care and watchfulness on the part of the engineers, would be almost impossible.

468 As all these signals work automatically, and are supposed to be of great importance to railroads in the prevention of accidents, thus saving life and property, the question of reliability is all important. It is upon this point especially that you desire my opinion. The combinations of the magnets, signals, and bells, the circuit closers and openers are all extremely simple. There are no compensating balances, springs, or adjustments which are liable to get out of order. With the motive power, the battery, in order they seem perfectly reliable, and of this there should be no question, as the form or kind of battery used is constant, powerful, and lasting. It will run fifteen or twenty days without being even touched. It should, however, be examined frequently to see that the connections are secure, etc. With this precaution I can discover no reason why they should not be perfectly reliable and to be depended upon at all times.

Yours, most respectfully, W. O. LEWIS.

THOMAS S. HALL, recalled:

Q. 1. When did you first become acquainted with Edwin D. McCracken, or have any communication with him?

A. Some time during the last four months; I should say in the month of March, possibly in April.

Q. 2. When did you first hear there was such a man, and from whom?

A. I first heard of Edwin D. McCracken through Frank L. Pope, by his testimony in this case relating to said McCracken, at Hartford.

Q. 3. Do you wish to make any further statement or correction of your previous testimony in regard to the date when Mr. Hendrickson ceased to be in your employment?

Objected to, as incompetent.

A. I do; I wish to correct the date given in my direct testimony on page 110, folios 423, 424, and 425, by stating that Stephen C. Hendrickson was employed by me in erecting my signal apparatus on the New York & New Haven railroad until some time in
469 December, 1869. That we had put in operation the application shown by diagram Exhibit 1 A. After completing this application we were engaged in making a similar application to that represented in Exhibit 1 A, at a crossing near Stamford station, called Cove Crossing. We had perfected this work so far as making the application to both tracks of the New York & New Haven railroad, in connection with a visual and audible signal which was located at said crossing. We also had run the insulated wires to five points on the New Canaan railroad, which runs parallel with the New York and New Haven railroad, for the purpose of being attached to track circuit-closers, in order to operate the same signals. There came up a severe snow storm, which prevented us from attaching the wires to the circuit-closers, and thus completing the work. At this time, on account of the severe weather, Mr. Hendrickson went home, with the understanding that he was to return and finish the job as soon as the weather would admit. Some time before the 20th of April, 1870, he did return for the purpose above named. It was at this time that I received the information which led me to discharge Mr. Hendrickson, as stated previously on my examination-in-chief.

Q. 4. About how long before April 20th, 1870, did Mr. Hendrickson return to Stamford to finish the job?

A. I am very positive that it was before March 22d, the date that Mr. W. O. Lewis examined the application. I have no means of knowing the exact date. It was in January, February, or March, when the weather got warm enough to work again.

Q. 5. How long was Mr. Hendrickson at Stamford working for you at this time before you discharged him?

Objected to, as not in reply to any evidence complainant has introduced.

A. I am not positive, but am very strongly impressed that he was discharged either the first or second day, as the work that he came to finish remained in an unfinished state until the following May or June, 1870. I mean the unfinished work of applying the circuit-closers to the New Canaan track.

470 Cross-examined by Mr. CHAMBERLIN:

C. Q. 6. Have you on your books an account with Hendrickson for work done by him and cash paid by you?

A. I had, but have not at the present time.

C. Q. 7. What has become of that account?

A. I had a dishonest book-keeper who seized all my books and accounts relating to the signal business up to a stated time, and I was never able to obtain them from him.

C. Q. 8. Up to what time?

A. I shall have to ask for a little time to enable me to answer your question, which I will do as soon as possible. I now find, by referring to the documents which I have referred to, that my books were probably seized some time early in the year 1869. After that time my signal accounts were kept by myself, and I am unable to say where those early accounts are at the present time, or whether I shall be able to produce them or not.

C. Q. 9. Have you referred to them since your former testimony to assist you in fixing the date at which Hendrickson performed his last work for you, or when you paid him therefor?

A. I have not.

C. Q. 10. Upon what aids do you rely then in correcting your former testimony and swearing that Hendrickson worked for you after December, 1869?

A. Upon the aid of my recollection, and circumstances connected immediately with the case.

C. Q. 11. Any circumstances other than those you have stated in your testimony to-day? If so, state them.

A. While we were at work in the month of December, in applying the signals to the Cove Crossing, as stated in my previous testimony, and while the work was only partially completed, there came up a very severe snow storm, so much so that we were obliged to quit the work. There had several inches of snow fallen, and when on my way from the work at the Cove crossing, accompanied by some one who I think was Mr. Hendrickson, we were walking down the railroad track, when, near the Stamford depot, in attempting
471 to step over a cattle-guard, which was built of stone, owing to a piece of stone being broken out at the place where I stepped, I slipped and fell my whole length, bring one of my legs in contact with a stone, which injured me so badly that I had to be helped to my house and send for a doctor. Mr. Hendrickson went home at this time, and we did nothing farther to the work until the following early spring or late in the winter.

C. Q. 12. Why do you think Hendrickson was with you when you hurt your leg?

A. I am positive that he worked up to this time, as I did not employ any one else excepting him to run my wires and assist in adjusting my instruments, unless it was a common laborer.

C. Q. 13. Please read our Exhibit T now handed you, and say whether you paid Mr. Hendrickson any money after that alluded to in that letter, or whether he worked for you as you have stated

in your previous answer to-day after the time referred to in that letter.

A. Mr. Hendrickson did work for me after this time for a part of one or two days, and I paid him in money for the said work on the platform of Stamford Depot.

C. Q. 14. When and where, after looking at that letter, do you now say he worked for you a day or two for which you paid him cash as you have stated?

A. He worked for me the time above stated in the winter or early in the spring of 1870. He had commenced to finish the work at Cove Crossing that we had left unfinished when the severe weather came on the previous December.

Adjourned to June 20, at 10 a. m.

NEW YORK, *June* 20, 1879.

Redirect examination by Mr. VAN SANTVOORD:

Q. 15. Can you give the particulars of the work of applying the signals to Cove Crossing, and of making the application of your signal system to which you refer in answer to C.-int. 11 as being partially completed in the month of December, (1869,) and have you any documents which will aid or confirm your recollection in those matters?

472 Objected to, as cumulative of witness' testimony-in-chief yesterday, as immaterial, as not in reply to the case or any portion thereof made by complainants in their reply.

A. With the aid of documents that I believe I have in my safe, at Meriden, Conn., I think that I can give the particulars of the application of my signal system at the Cove crossing more fully and clearly than I can otherwise do.

Q. 16. When can you examine them, so as to be ready to proceed with your examination?

A. The earliest possible time that I can examine them will be this evening. The time that it will take me to prepare to go on with my examination I am unable to state.

Q. 17. Can you examine them and be at New Haven to-morrow morning by 12 o'clock, to proceed with this examination in Mr. Baldwin's office, at New Haven?

A. I now know of nothing which will hinder me from so doing, and will use my best endeavor to do so.

Defendants' counsel gives notice to complainants' counsel that the further examination of this witness will proceed, if complainants' counsel has no objection, to-morrow at 12 o'clock noon, at Mr. S. E. Baldwin's office, in New Haven.

To which arrangement complainants' counsel agrees, and consents to attend.

473 *Evidence in Rebuttal in Behalf of Defendants.*

Circuit Court of the United States, District of Connecticut.

ELECTRIC RAILROAD SIGNAL COMPANY
vs.
THE HALL RAILWAY SIGNAL COMPANY.

Redirect examination of THOMAS S. HALL resumed at office of Simeon E. Baldwin, Esq., in New Haven, at 12 o'clock on June 21, 1879, pursuant to adjournment. Present: F. Chamberlin, Esq., for complainants; Simeon E. Baldwin, Esq., for defendants.

Deposition taken by the undersigned, as notary public, by consent of the parties.

Redirect Q. 18. Have you found any papers since yesterday in reference to the time of Mr. Hendrickson's employment by you in your signal business?

A. I have. I have found a letter dated Williamsburg, July 27, 1868, from him to me.

Defendants lay in this letter, as marked "Exhibit No. 51, Hendrickson letter. George L. Dickerman, N. P."

Q. 19. About when did you receive that letter?

A. About July 28, 1868.

Q. 20. How long previous to that had Mr. Hendrickson been in your employment, or in that of the company you represented in the signal business?

474 A. At least one month.

Q. 21. Where had he been at work during that time?

A. On Flushing and North Side railroad.

Q. 22. Who is the Mr. Poppenhausen named in that letter, and what was then his business?

A. He was a son of Conrad Poppenhausen, whom I understood at that time to be the principal owner of the Flushing and North Side railroad. The young man was the general manager of the Flushing and North Side railroad, and was the person that I traded with in regard to the use of my signal system at that time.

Cross-examination not desired.

THOMAS S. HALL.

Taken and subscribed at New Haven, this 21st day of June, A. D. 1879, before me, as witness my hand and notarial seal this day affixed.

[L. S.] GEORGE L. DICKERMAN,
Notary Public.

Exhibit No. 51, Hendrickson Letter. George L. Dickerman, N. P.

WILLIAMSBURG, *July* 27, '68.

Mr. T. S. HALL.

DEAR SIR: Yours of June 23d at hand, it having been delivered

to another party in my absence; also letter of July 22d, and one in care of Mr. Poppenhausen rec'd.

One of the houses is finished ready for the signal-case. The carpenters have been taken away again, and cannot go on with the job. I shall go on and put it up myself at once. If I get the house done this week, I shall be able to finish all next week.

Mr. P. wishes me to put up a short line of telegraph from Flushing to College Point.

I will meet you at 27th street depot on Friday morning, on arrival of the 9.30 train; will be at the telegraph office.

Very respectfully, S. E. HENDRICKSON.

And on the 5th day of April, 1881, opinion of court was filed, in the words and figures following, viz:

475 Circuit Court of the United States for the District of Connecticut.

THE ELECTRIC RAILROAD SIGNAL COMPANY
vs.
THE HALL RAILWAY SIGNAL COMPANY.

SHIPMAN, J.:

This is a bill in equity to restrain the defendant from the alleged infringement of letters patent No. 140,536, issued to Frank L. Pope, on July 1st, 1873, and now owned by the plaintiffs', for improvements in circuits for electric railroad signals.

Before the date of this invention, electro-magnetism had been utilized for the automatic actuation of signals denoting both danger and safety upon the line of a railroad. By Johnson's patent of 1858, a single battery was mounted on each train, and was applied to turn the signals in succession. Each signal was operated alternately by two electro-magnets, one to turn it to "danger," and the
476 other to turn it to "safety." This plan required a battery for each train. Under Clark's patent of 1861, the signals were operated by the action of a railroad train, but his apparatus made use of a special battery and an independent electric circuit for each signal. The system of Thomas S. Hall, which was used on the Harlem railroad in 1871, moved the signals by stationery batteries, and required two batteries to operate each signal.

The object of the system which Pope patented was to operate automatically a series of signals, in definite and predetermined succession, by the passage of a train, making use of a single battery. The patentee says in his specification: "My invention consists in a peculiar arrangement of electric circuits in combination with a battery, and with two or more circuit-closers operated by moving trains or otherwise, whereby a series of two or more visual or audible signals, situated at intervals along the line of a railroad, may be operated by currents of electricity derived from a single battery,
477 thereby obviating the inconvenience and expense of employing, as heretofore, one or more separate batteries, situated at or near each signal for the purpose of actuating the same."

The record shows that the invention was a new combination of old devices whereby a novel and useful result was produced, and was patentable.

It is assumed that the same invention was placed on the Eastern railroad of Massachusetts by the defendant, a corporation which has been engaged in the manufacture and erection, upon different roads, of signaling apparatus constructed in accordance with various patents of Thomas S. Hall, and that the change, which was made, whereby the earth was used as a part of the circuit, was not a material change or modification of the invention. Letters patent to Hall & Snow, No. 165,570, dated July 13th, 1875, describe the defendants' method of electric circuits.

Upon this assumption, the main question in the case is that
478 of priority of invention, for it will be manifest that Pope and Hall were each independent inventors of the one-battery system, and that each mentally conceived the same plan, in substance, in the summer and fall of 1872.

Hall is the father of the plan of electric railroad signaling apparatus which is in use in this country, and in 1872 was actively engaged in studies and experiments and in the practical application of the system which he had then introduced upon the Harlem railroad. In the same year, Messrs. Pope and Hendrickson were actively engaged in attempts to introduce electric signals upon different roads, and in the summer and fall were employed on the line of the Pennsylvania railroad in Pennsylvania. They were thoroughly in love with the business, were active, energetic, self-reliant, fertile in invention, and were diligent to secure by letters patent the result of their inventive skill.

During this time, at the suggestion of one of the officers of the railroad company, Pope had constructed a device by which a primary and secondary signal were operated from the same battery.
479 This device suggested to his mind another idea, and during the week prior to Nov. 6th, 1872, he first described to Hendrickson the plan of working a series of signals along the line of a railroad by the use of a single battery. This conversation took place in a jeweller's shop while they were waiting to have some broken wires resoldered, and as they went from the shop to dinner. It was the first definite manifestation or expression of the idea which Pope had in his mind, and establishes the date of the time when he mentally reached the result which was afterwards shown in his application for a patent. He made neither tests nor models nor experiments. His mental result was not reduced, and was not attempted to be reduced, to practice. He intended to test the system before making application, but did nothing of the kind, and after April 25, 1873, he prepared his application, which was filed May 15, 1873. The system was not afterwards placed by Pope upon any road, and there is no evidence that anybody else, professing to act under this patent, has ever reduced it to practice, except that Pope con-
480 structed a working model of the whole apparatus in 1875 or 1876, which was set up in his shop in the city of New York.

The patent having been granted to Pope, and now being attacked

on the ground that the patentee was not the first inventor, it is not enough for the defendant to show that Hall had conceived the same idea, and had made drawings or models and experiments with his models, but the defendant must establish that Hall reduced what he conceived to practice in the form of an operative machine, and embodied it in some practical and useful form before Pope made his application, it being a fact in the case that Pope had not reduced his idea to practice before his application. (Ellithorpe *v.* Robertson, 2 Fisher, 85; Union Sugar Refinery *v.* Matthieson, 3 Cliff., 639.) The law on the subject of the priority of right between two independent inventors is substantially as it was laid down by Judge Story in Read *v.* Cutler, 1 Story, 590: "In a race between two independent inventors, he who first reduces his invention to a fixed positive and practical form would seem to be entitled to a priority
481 of right to a patent therefor. The clause of the fifteenth section, (of the act of 1836,) now under consideration, seems to qualify that right by providing that in such cases he who invents first shall have the prior right, if he is using reasonable diligence in adapting and perfecting the same, although the second inventor has, in fact, first perfected the same and reduced the same to practice in a positive form." (White *v.* Allen, 2 Fisher, 440; Reeves *v.* Keystone Bridge Co., 5 Fisher, 456; Agawam Co. *v.* Jordan, 7 Wall., 583.)

Hall, during the summer of 1872, was thinking over the same idea which Pope had, and about December 21st, 1872, came to the mental result that a one-battery system was feasible. He forthwith wrote to his son, who was in Boston, to join him in Meriden. The son complied with the request, and, with the assistance of other employees, made a working model, in accordance with his father's instructions, in the upper room of the defendant's shop. Hall, as manager of the defendant corporation, was constructing at this time for the Eastern Railroad Company his system of signals upon
482 the manifold-battery plan. Early in January, 1873, he described the new plan to the manager of the company, who agreed that it might be placed upon his road in lieu of the old plan at the defendants' expense, if not subsequently approved. About January 20th, 1873, Hall telegraphed to Geo. H. Snow, his assistant, to stop work on the railroad and come to Meriden, where he was employed upon the signals and instruments which the new plan required, till the fall of 1873. In the latter part of April, 1873, a new track circuit-closer was placed on the down track of the Hartford and New Haven railroad at Meriden, and a line of telegraph poles was extended to the shop, about an eighth of a mile away. Upon these poles wires were put, which connected with the track and the battery in the shop. The signals were properly arranged and were operated by all the down trains on the road. The mechanism remained in position for months. The arrangement described in Pope's patent and this Meriden arrangement were substantially the same.

Subsequently, in December, 1873, after the new track cir-
483 cuit-closers were finished, Snow went to the Eastern railroad to put the new system in operation. Here a practical diffi-

culty was experienced, which is thus explained by Alvah W. Hall, the son of T. S. Hall: "The first difficulty we found was that the magnets, being wound with coarse wire, and thus adapted for the short circuits, and comparatively weak batteries, with which they had previously been used, required too much battery power to work them on a long circuit; therefore, when a battery was applied strong enough to work the most distant signal, which signal would have the longest circuit of any of them, it made the current too intense, when the signal nearest the battery, which would be on the shortest circuit, was operated, to work satisfactorily. The spark, on breaking contact with the circuit-closer of this short circuit, following in a burning flame between the points of the circuit-closer after the said points were removed from each other their proper distance, destroyed *to* points and burned them up." A change was made on February 14th, 1874, which obviated the difficulty, and which mainly
484 consisted in bringing the ground into use to form part of the circuits. This is the change which the plaintiffs insist was simply mechanical in its character, and which the defendant claims made its combination a new invention. Subsequently the system of Mr. Hall was introduced upon other railroads, and a large amount of money was paid to his company therefor.

I am clearly of opinion that the application of the one-battery plan to use on the Hartford and New Haven railroad in April, 1873, was the reduction to practice in the form of operative mechanism, as distinguished from models, and was the embodiment of the idea in a practical and useful form, as distinguished from experiments, which the law requires. The mechanism to be used was of a peculiar character. It must be used upon and by the aid of a railroad, moving trains of cars as a part of the machinery. It is not to be expected that the inventor could induce the owners of a railroad to expend money on an extensive scale in a new enterprise, neither could he be reasonably expected to place expensive structures upon miles of railroad track. It can only be reasonably required that
485 the entire system should be subjected to practical, daily, and continuous use upon a railroad by whatever trains pass upon the track. Hall reduced the invention to practice prior to Pope's application and while, so far as Pope was concerned, the new plan rested in theory.

The plaintiffs rely upon the qualification of the rule that he is the first inventor who has first actually perfected the invention, the qualification being that if the one first to conceive of the invention was at the time using reasonable diligence in adapting and perfecting the same, he is recognized as the first inventor, although the second to conceive may have been the first to reduce to practice. It is also true that the determination of the fact of diligence is not to be reached by comparison of the diligence of the two inventors. If Pope was reasonably diligent in perfecting his idea, it does not matter that Hall was exceedingly diligent and made more rapid advances.

The plaintiffs' position is that Pope had mentally worked
486 out his invention by the first week in November, 1872; that

Hall had reached the same result in the latter part of December, 1872; that Pope applied for his patent on May 15th, 1873; and that there was no laches in this respect. All this is true; and if meanwhile he had been engaged in efforts to perfect his invention, his right to the patent could not be assailed on the ground that another was the first inventor.

It was an important step in this invention to originate the idea of the one-battery system. It was more important and more difficult to overcome the practical hindrances which lay in the way of a successful application of the idea. An examination of the testimony will show that Pope did nothing to perfect what he had accomplished until he applied for his patent. He explained his plan to Hendrickson about Nov. 6th, who thereupon drew a very rude and scanty pencil sketch which Pope said represented his idea. On December 3d, 1872, Hendrickson showed Pope a rough drawing of an improved signal machine, which he (Hendrickson) had de-
487 vised, and which he thought would be well adapted to be used in connection with the one-battery plan. Pope was favorably impressed with the sketch and told Hendrickson to prepare a working model at once, and he, Pope, would prepare an application for a patent for the machine. The model was tested and found to work well, and Pope says: "I immediately proceeded to prepare an application for a patent, which was filed in the Patent Office on the 26th of December, 1872. * * * As this signal was equally well adapted to be used in connection with the system of circuits which we already had in operation on the Pennsylvania railroad, and on the Lehigh Valley Railroad Company, at Bethlehem. I described in the specification the signal as working in a system of this description, making no allusion to the proposed plan of working a number of them from a single battery, as the particular arrangements of circuits had no necessary connection with the features of the invention, which were considered to be new, and which were intended to be covered by the claims. I intended to take out a separate patent on this system of circuits after I had an opportunity to test it, and therefore did not wish to make
488 any disclosure of it in the specification of the patent of another invent-on. During the latter part of November and the early part of December, 1872, I was also engaged in the preparation of an application for letters patent intended to embody the improvements which I had made in the machinery and system which we had placed on the Pennsylvania railroad; that is to say, the independent locking magnet, the cut-off for transferring the battery circuit from the main magnet to the locking magnet and secondary signal, the arrangement of the primary and secondary signals with reference to each other, and some other minor points. This application was completed about the 20th of December, and immediately upon its completion I took it to Washington myself and filed it on the 21st of December, 1872."

On or about Feb'y 10th, 1873, Pope had a conversation with Mr. A. G. Davis, superintendent of telegraphs on the Baltimore and Ohio railroad, in regard to the introduction of a signal system on that road,

and told Davis that he had devised a plan by which the re-
489 quisite number of signals on eight or ten miles of road could be worked from the battery, and that he was willing to undertake to do this at any time. In March a single signal was put up on the road, but it is evident that this signal was not put up as a sample of the one-battery system. Some time between February 10th and April 1st Pope had one or more conversations with Edwin D. McCracken in regard to the system, but giving to these interviews the weight which they have in Pope's mind, the conversations were simply an assertion of what he could do by this proposed plan. The only thing thereafter done was to make out the application. Mr. Pope says: "As the various parts of the combination, circuit-closers, signals, signal machinery, &c., had already been thoroughly tested in practice, and almost continually for over a year, it did not seem to me necessary to test the new combination in actual service before making an application for a patent, as it was a very easy matter for any competent electrician to calculate from existing data the amount of battery power, the size of conductors, and the proportionate electrical resistance of the different parts so as to insure the satisfactory operation of the system in practice. After completing
490 and filing an application for a patent on an improved track connection which had been invented by Mr. Hendrickson, and which was sent to Washington and filed on the 25th day of April, 1873, I prepared the application for the patent, which was issued July 1, 1873, as No. 140,536, and is Exhibit A. This application was filed as soon as the model was completed, and reached the Patent Office on the 15th of May, 1873."

During the period between Nov. 6th and May 15, Pope was busy, but he was not busy about this invention. He was occupied with other inventions, but he was doing nothing with this one. The just and equitable principle of the law which gives a patent to the inventor who first conceives of the invention, provided he is diligently engaged in perfecting it and adapting it to use, and overcoming the practical difficulties which are always to be surmounted before theory becomes fact. Although he was slower in the race than the one who was second to conceive, does not apply to Pope. Who faintly conceived the idea is not known. Pope first attained a mental result. After that, he was actively occupied in the same branch of
491 study, but he did not develop this system in wood and metal. Hall did develop it, made it useful and practicable, and achieved success. In my opinion it would be a great wrong to decide that the defendant is liable as an infringer.

Let the bill be dismissed.

Charles E. Perkins and Franklin Chamberlin, for the plaintiffs.
Simeon E. Baldwin, for the defendant.

And on the 26th day of April, 1881, the following final decree was made and entered in said cause, viz:

492 *Final Decree.*

At a stated term of the circuit court of the United States for the

district of Connecticut, in the second circuit, held at New Haven, in said district, on the fourth Tuesday of April, in the year of our Lord one thousand eight hundred and eighty-one.

Present: The Honorable Nathaniel Shipman, judge.

THE ELECTRIC RAILROAD SIGNAL COMPANY
vs.
THE HALL RAILWAY SIGNAL COMPANY. } In Equity.

This cause having come on to be heard at this term upon the bill of complaint herein, the answer thereto of the defendant, the replication of the complainant to such answer, and the proof, oral, documentary, and written, taken and filed in said cause, and having been argued by counsel for the respective parties—

Now, therefore, on consideration thereof, it is ordered, adjudged, and decreed, and the court doth hereby order, adjudge, and decree as follows, viz:

That the complainants' said bill of complaint be, and the
493 same is hereby, dismissed, with costs to the defendant, to be taxed.

N. SHIPMAN,
District Judge.

494 I, Edwin E. Marvin, clerk of the United States circuit court for the district of Connecticut, do certify that the foregoing is a true return of the record of said court in the cause of The Electric Railroad Signal Company against The Hall Railway Signal Company.

In witness whereof, I have set hereto my hand and the seal of said court, at Hartford, in said district, this 15th day of October, A. D. 1881.

[SEAL.] E. E. MARVIN, *Clerk.*

Endorsed on cover: Connecticut C. C. U. S. No. 141. The Electric Railroad Signal Company, composed of Frank L. Pope, Stephen C. Hendrickson & James D. Lincoln, surviving partners, appellant, *vs.* The Hall Railway Signal Company. Filed 26th October, 1881.

114-87

Supreme Court of the United States.

OCTOBER TERM, 1884.

No. 141.

The Electric Railroad Signal Company,
PLAINTIFF AND APPELLANT,

vs.

The Hall Railway Signal Company,
DEFENDANT AND APPELLEE.

APPEAL FROM THE CIRCUIT COURT FOR THE DISTRICT OF CONNECTICUT.

IN EQUITY.

BRIEF OF COUNSEL FOR APPELLANT.

GEO. H. CHRISTY,
CHAS. E. PERKINS,
Of Counsel for Appellant.

Supreme Court of the United States.

OCTOBER TERM, 1884.

No. 141.

THE ELECTRIC RAILROAD SIGNAL COMPANY,
APPELLANT,
VS.
THE HALL RAILWAY SIGNAL CO., APPELLEE,

IN EQUITY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE DISTRICT OF CONNECTICUT.

BRIEF OF COUNSEL FOR THE APPELLANT.

STATEMENT OF THE CASE.

This is a bill in equity brought by the appellant plaintiff below, to enjoin the appellee, defendant below, from the use of an invention secured to Frank L. Pope by Letters Patent of the United States, numbered 140,536, dated July 1, 1873, and assigned to the plaintiff.

The patent is found upon Exhibit Book, page 1, Exhibit A, and is for improvements in Electric Signaling Apparatus for railroads, and the nature of the invention is stated as follows in the specification.

"My invention consists in a peculiar arrangement of electric circuits in combination with a battery and *two or more* circuit-closers operated by moving trains or otherwise, whereby a *series of two or more* visual or audible signals, situated at intervals along the line of the railroad may be operated by currents of electricity derived from a *single battery*, thereby obviating the inconvenience and expense of employing, as heretofore, one or more separate batteries situated near each signal for the purpose of actuating the same."

As is more fully shown hereafter when we consider the state of the art, in 1872–3 signals worked by means of the electric force had been well known for a long time. All the means used for actuating them, such as track circuit-closers, visual and audible signals, batteries, conductors, etc., of many different varieties had been used, and the method of actuating the signals by electric currents through circuits opened and closed by moving trains, was also well known; but up to this time a separate battery, a separate circuit-closer, and a separate circuit had been required for each signal, causing great expense, and subject to many disarrangements and inconveniences.

Pope's invention consisted, in general terms, in the construction of an apparatus wherein all the separate circuits of the old apparatus were thrown into or made parts of, one single main operating circuit, so that such single main operating circuit with its branches, was made to do the work of all the separate circuits previously used, and one single battery was made to do all the work of the series of batteries, previously used. Hence he made the new combination of a *single* battery, and a single branch of main operating circuit, in lieu of the old combination of a *series* of batteries, and a *series* of independent circuits,—the other elements of track circuit-closers, signals, and electro-magnets, essential in actual use, remaining substantially as before.

The claims are as follows:

"1. The battery B, in combination with the positive and negative conductors, C and Z, two or more electric magnets

M, M, M, for actuating or causing to be actuated visual or audible signals, and two or more circuit closers, *a*, *a*, *a*, placed at intervals along the line of a railroad, substantially as and for the purpose specified.

"2. The battery B, in combination with the positive and negative conductors C and Z, two or more electro-magnets *m*, *m*, *m*, for releasing or reversing visual or audible signals, and two or more circuit-closers, *a*, *a*, placed at intervals along the line of a railroad, substantially as and for the purpose specified.

"3. The combination of the battery B, conductors C and Z, circuit closer a, and electro-magnet M, for actuating a visual or audible signal, with the circuit-closer *a*, wires 5, 7, and 8, and electro-magnet *m*, for reversing, releasing or stopping said signal, substantially as specified."

The method of operation of these separate elements is fully explained in the specification, and is substantially as follows:

At intervals along the line of a railway track, signals are placed, such for instance as can show a sign of either "danger" or "safety." Any desired number of these signals, two or more, are by a suitable electric conductor, connected together, and to a battery common to both or all. The usual electro-magnets are employed in connection with each signal, and suitable circuit-closers are arranged in, or in convenient proximity to, the track, one at each signaling point, so as to be operated by a passing train. Then, when a circuit is formed or "closed" through any one of the signal magnets, the electric current passes through such magnet, and gives it a magnetic power which, by suitable and well-known mechanism causes the signal to be displayed. When this circuit is broken, the power of the magnet ceases, and the signal falls back to its original and normal position, which is generally "safety." This action of making and breaking the circuits may be caused in many well-known ways. The way mentioned in the patent is by having a section of the track insulated and one rail connected with one end or "pole" of the conductor and the opposite rail with the other, so that the wheels and axles of the cars, while passing over them, complete the connection between the two ends or "poles" of the

conductor, and thus close the circuit. This causes an electric current to pass through the magnet and actuate the signal so that it shows "danger," and this signal remains displayed till the train reaches the next signal, when by a similar arrangement this second signal is by a like action shifted to "danger," and the first signal is put back to "safety."

The engineer of the succeeding train seeing each signal show "safety," proceeds on his way until he comes to a signal which has been shifted to the "danger" position by the action of the preceding train and which has not yet been reversed or shifted back, thus showing that such preceding train has not yet reached the next signal beyond, but is somewhere between the two, and so near as to render it dangerous for the second train to proceed.

All this could have been done, and was done previously, by having one battery for each signal, but Pope invented such a combination of these old elements that *one battery* and one main circuit could be employed to actuate a large number of these signals.

The plaintiff's bill alleged an infringement of this patent by the defendants, and upon the hearing he introduced the evidence found upon pages 12 to 21 of the Record, and rested.

The answer of the defendant denied that Pope was the first inventor of the improvement described in his patent, and alleged that one Thomas S. Hall was the first inventor. It also alleged that the invention was described in various English and American patents mentioned, ranging in dates from 1854 to 1872. That what Pope claimed was not an invention at all, and would not work in practice, and that his specifications did not properly describe the invention. They also referred to some patents as showing the state of the art before 1873.

More or less evidence was introduced by the defendant under each of the issues so made, but the principal contro-

versy, and the one upon which the court below decided the case for defendant was, whether Pope or Hall was the first inventor.

Upon this point, Pope claims, and, as we contend, our proofs show, that he made his invention November 6, 1872. He had a drawing made at that time showing exactly what the drawing annexed to his patent contained. He applied for his patent in May, 1873, it was allowed in June, and issued July 1st of that year.

The defendant's testimony tended to prove that Hall mentally conceived a similar invention about December 22, 1872, and at that time made a model of it; and it is further claimed that in April, 1873, he put his invention into actual practical use upon a railroad.

The court found as deductions of fact from all the testi mony that Pope did make his invention November 6, 1872, and had a drawing made of it, which sufficiently described it; that Hall made the same invention December 22d, and had a model made of it; that in April, 1873, he put it "into actual operation in wood and metal" on a railroad; and from these facts he drew a legal deduction that Hall was *in law* the first inventor.

ERRORS OF THE COURT BELOW.

The appellant claims that the court below erred in two particulars, one of fact and one of law.

The Court finds that Pope invented the combination patented by him, during the first week of November, 1872, and then described it to a Mr. Hendrickson, who, from his description, made two drawings which sufficiently showed the invention. Pope was at the time engaged in obtaining letters-patent for other inventions theretofore made by him, and, as the Court finds, without unreasonable delay, about the 25th of April, 1873, less than six months after making the invention,

prepared his application, filed it in the Patent Office May 15, 1873, and the patent was granted July 1, 1873.

He then goes on to consider what Hall did, and finds that about *December* 21, 1872, he had an idea of a system of signals similar to the plan of Pope, and soon after described it to his son, who made an arrangement of wires, etc., upon the wall of a shop, showing the operation of the plan, and some time in the latter part of April, 1873, connected this shop-model with a railroad track about an eighth of a mile distant, so that the passage of the cars operated a signal placed in the shop.

Upon these facts the plaintiff claimed the law to be, that Pope's invention was made complete when he so described it and reduced it to the form of a drawing November 6, 1872; that if, as we contend, and as the proofs show, he thereafter exercised reasonable diligence in applying for and procuring his patent, no subsequent inventor could by experimental tests, or even by actual use, subsequently though intermediately made, deprive Pope of his prior right. And if it further appears that during the interval between the making of the drawing and the application for the patent, the inventor was engaged actively in adapting the invention to public use, or in otherwise perfecting it, or even in efforts to secure its introduction, such considerations will go far to establish such priority of right, and also tend to show not only a reasonable but the utmost diligence. So long as reasonable diligence in applying for a patent was shown, his right of priority was unassailable. And plaintiff also contended, as matter of fact, that what Hall did between the dates of Pope's invention and application, was not a working of the invention, nor even an experimental embodiment of it. The court, while it found in substance that Pope made the invention at the time we contend, and also found that he exercised due and reasonable diligence in applying for and procuring his patent, notwithstanding these findings, still further held that as Hall was the first to reduce the invention to practice, and did so about

a month before Pope's application was filed, that *on that account alone* Pope's priority of right must give place to Hall's. Independently of all questions of fact in dispute, and even on the facts as the court found them, we do not understand this to be the law.

Hence we believe that the court below erred in its finding as to matters of fact, and still further erred in the application of the law to the facts. We contend that a mere delay of a little over six months in filing an application for a patent, in the absence of knowledge of an adverse claim, cannot be held, as a conclusion of law to operate as a postponement of the priority of such inventor in favor of a subsequent inventor.

We contend, that as appears from the proofs, Pope was otherwise engaged, during the period in question, in adapting his invention to public use, and was making diligent efforts to secure its practical use, and that he thereby showed such abundant diligence, that his right of priority cannot be postponed in any body's favor. We further contend, that as between Pope and Hall, the question of what is reasonable diligence is to be liberally applied as regards Pope's rights, much more so in fact than as regards Hall.

And we further contend that the rule of law as between rival inventors, one of whom has patented his invention, is not as laid down by the court below.

These are the principal questions in the case, though we shall consider briefly the questions of infringement, etc., which are set up in the answer.

ARGUMENT.

We will consider the case under the following heads:

I. The subject of Patent.

II. The invention by Pope.

III. The acts done by Hall.

IV. The other claims set up in the answer as to prior invention.

V. The other objections to the validity of the patent.

VI. The question of infringement.

I.

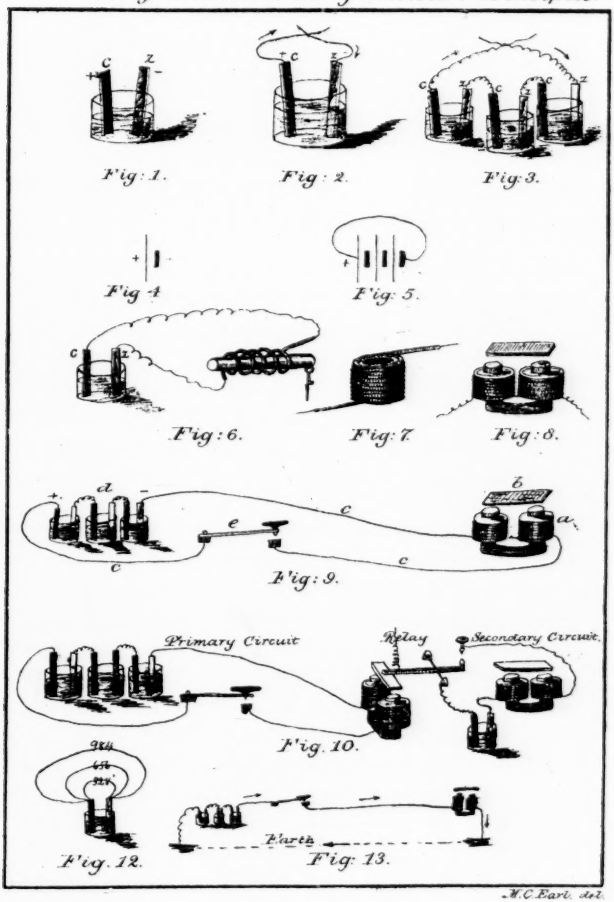
THE SUBJECT OF THE PATENT.

The invention described in this patent is for the working of danger and safety signals upon a railroad by the application of electricity or electro-magnetism, by means of a new combination of mechanical devices. It is described in the letters patent as follows:

"My invention consists in a peculiar arrangement of electric circuits, in combination with a battery and with two or more circuit closers operated by moving trains or otherwise, whereby a series of two or more visual or audible signals, situated at intervals along the line of a railroad, may be operated by currents of electricity derived from a single battery, thereby obviating the inconvenience and expense of employing, as heretofore, one or more separate batteries situated at or near each signal for the purpose of actuating the same."

The testimony and the letters patent introduced require for their proper understanding some more accurate knowledge of the principles of electricity, and of the meaning of various technical words and phrases used in electrical science, than is general, and we will therefore make a brief statement of a few of the principles of electro-magnetism, and of the meaning of such technical expressions as appear necessary in order to fully understand the discussion, and we also insert some diagrams illustrating them.

Diagrams Illustrating Electrical Principles.



STATEMENT OF ELECTRICAL PRINCIPLES AND DEFINITIONS.

If two plates of different metals, pure zinc and copper for example, be immersed in an acidulated or saline solution (Fig. 1) no sensible action occurs as long as the metals do not touch each other; but the moment they come in contact, and as long as they remain so, the zinc is chemically attacked and dissolved, and an electric action is thereby produced.

When the two metals are connected by a wire, say of copper, the effect is the same as if they touched directly. In both cases an electric *circuit* is said to be formed consisting of the two metals and the liquid. In the case last mentioned the wire is said to *complete* the circuit. The wire is also said to be the vehicle of an electric current which flows around the circuit (Fig. 2).

A pair of plates of dissimilar metals, immersed in an exciting solution, is called a galvanic or voltaic element or cell, and frequently a battery, which, however, is a term properly applicable only when a number of cells or elements are united in order to obtain increased force (Fig. 3).

If a naked wire forming part of such a circuit be bound round a bar of iron, the current will in great part pass through the iron, which now becomes part of the circuit.

But if the wire be first overspun with cotton or silk, the passage of the current from the wire to the bar is prevented. In this case the current is compelled to pass successively through all the convolutions of the wire. A wire thus overspun for the purpose of confining the electricity thereto, is called an insulated wire (Fig. 6).

Now the iron bar, though not in the circuit, is powerfully affected by the surrounding wire. Every convolution of the wire when traversed by the current, evokes a certain amount of magnetism in the bar, and by rendering the convolutions sufficiently numerous, a magnet of great strength may be formed. Such a magnet is called an electro-magnet, to distinguish it from the ordinary permanent steel magnet (Fig. 6).

When the circuit is interrupted at any point, the current

instantly disappears, the power of the electro-magnet ceases, and the iron returns to its ordinary inert condition.

In practice the insulated wire is coiled upon a hollow bobbin like a spool of thread, several layers of convolutions being superposed upon each other, forming what is called a helix or coil (Fig. 7).

The iron bar is placed within the helix, forming its core. The electro-magnet may be straight, or of other forms. Ordinarily it resembles an U, and is termed a horse-shoe magnet. A bar of iron upon which the electro-magnet exerts its attraction is called its armature. The end of the bar, or points where the attractive force is principally manifested, are called its poles (Fig. 8).

To all appearances, the wire completing the circuit, if tolerably thick, is unchanged by its connection with the zinc and copper plates. But if a very thin wire is substituted for the thick wire, the former is sensibly heated, and with a current of sufficient power it may even be fused.

The wire, therefore, is the vehicle of some force or condition which is competent to produce both magnet and thermal phenomena.

When the two metals in a battery are united by a conductor, such as a wire, an electric current is said to pass from one to the other.

The wire, and in fact all conductors, offer a certain *resistance* to the passage of the current.

For convenience in making electrical measurement and calculations, *units* of measurement have been established, as follows:

The *unit of electro-motive force* is called the *volt*, and is nearly equivalent to the electro-motive force of a cell composed of a piece of zinc and a piece of copper, immersed in a solution of sulphate of copper—i. e., the ordinary "gravity battery."

The *unit of resistance* is called the *ohm*, and is equal to the resistance of about 332 feet of iron wire of the size known

as No. 9, and 0.148 inch diameter, or of about 2150 feet of copper wire of similar dimensions.

The *unit of electro current* is called the *ampere*. It is equivalent to the strength of current which is produced by an electric-motive force of 1 volt acting through a resistance of 1 ohm.

The mathematical relations of these three units are as follows:

$$\frac{\text{Volts.}}{\text{Ohms.}} = \text{Amperes.}$$

From which it will be seen that:

(1.) With a given electro-motive force, the strength of current in a closed circuit is inversely in proportion to the whole resistance of that circuit.

(2.) With a given resistance, the strength of current in a closed circuit is directly in proportion to the electro-motive force which produces it.

It has also been found by experiment that within the ordinary conditions of electro-magnetic machinery:

(3.) The attractive force of an electro-magnet is directly proportional to the strength of the current in the circuit.

(4.) The heat developed in any given portion of the circuit is directly proportional to the square of the strength of the current in the circuit.

In order to operate a piece of machinery, for example a railroad signal, at a distance, by electro-magnetism, the following appliances are necessary. (See Fig. 9.)

a. An electro-magnet surrounded with coils of wire.

b. An armature upon which the force of the electro-magnet is exerted in order to actuate the signal.

c. A circuit of conductors extending from the electro-magnet which actuates the signal to the point from which it is to be actuated, and back again to the electro-magnet.

d. A battery for generating the current to operate the electro-magnet.

e. A device technically known as a key or circuit-closer for closing and breaking the circuit at the initial point for

operating the signal. It is nothing more than a convenient mechanical device, for uniting the several ends of the circuit-wires.

In order to produce the most favorable results in practice, the various parts above enumerated must have a certain quantitative relation to each other. For example: It required a certain ascertainable force to move a signal-disc of proper dimensions a certain distance in a certain time, in order to display or conceal it. This requires that a certain power be exerted by the electro-magnet to effect this movement. This again requires that a current of a certain strength should pass a certain number of times around the iron of the electro-magnet.

As the strength of current is determined by the ratio of the electro-motive force to the resistance, a sufficient number of battery elements must be employed to overcome the resistance of a circuit of the required length. A large wire offers less resistance to the current than a small wire, and therefore requires less electro-motive force or battery power to produce a given magnetic attraction, and *vice versa*. Whether a given result may be best attained by enlarging the conductor or the battery, is solely a question of relative economy under the particular circumstances of the case.

In producing mechanical power at a distance by electro-magnetism, a device known as the *relay* and *combined circuits*, is often used, especially in telegraphy. If the operating battery is situated close to the electro-magnet which is to do the work, the circuit may be made very short, and of little resistance; hence a small battery under these circumstances will develop a powerful magnetism. A key may be arranged to open and close this circuit, and this key may be operated by another magnet. This last magnet may be operated from a distance by a weak current, induced by an electro-motive force so small as to be utterly inadequate to do the work required in the first magnet. The key which is thus opened and closed by the action of an electro-magnet, is technically termed a *relay*, and the circuits are called the *primary* and

secondary, or in some cases, the *main* and *local* circuits. (Fig. 10.)

The current of a battery may be divided between two or more conductors, which are variously known as *branch*, *derived*, or *shunt circuits*. In cases of this kind the total current distributes itself among the several channels open to it, *inversely, in proportion to their resistance*. Suppose, for example, a battery having three circuits attached to it of No. 9 iron wire, respectively 328, 656, and 984 feet in length, the respective resistances will be 1, 2, and 3 ohms, while the proportion of the total current produced by the battery going to each branch will be respectively $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{6}$, from which it will be seen that a much larger proportion of the total current goes through the circuit of least resistance. (See Fig. 12.)

It is obvious, however, that the resistance per unit of any wire must vary directly as the amount of metal contained in it, or in other words, as the area of its cross-section. Therefore, if we substituted for the short branch of 328 feet, a wire of the same length and one-third the weight per foot, its resistance would equal that of the long wire of 984 feet length. Thus, by using appropriate sizes of wire, a circuit of any length may be made *equal in resistance* to a circuit of any other length. In this way a current may be made to divide itself equally between any number of branches, and each branch will be to all intents and purposes a separate circuit. In practically applying this device, the smaller wire is usually wound on a bobbin like Figure 7, which is termed a *resistance coil*.

It was discovered in 1837 that for circuits of considerable length, the earth might be made part of the circuit, thus dispensing with a special return wire, and from motives of economy and convenience, telegraphic circuits have ever since been, as a general rule, arranged in that way. Although the material of the earth is specifically a poor conductor, yet its volume is so great that its resistance is practically nothing (Fig. 13).

The application of electricity in various ways for actuating

railroad signals has been long known and used, both in this country and abroad, and Pope's invention, like many others, is only for an improved method of using these powers. The devices used by him, separately considered, are old, and the invention consists in a new combination of these old elements, by means of which a novel and better method of working these signals is obtained than was before known.

In order to ascertain exactly what was known before, both for the purpose of construing the patent, and to determine if it contained a new invention, we will make

A REVIEW OF THE STATE OF THE ART.

The various exhibits which have been introduced in evidence, enable us to determine very accurately what the actual state of the art was at the time this invention was made.

The object of the invention is to preserve a definite minimum interval of space between successive trains moving in the same direction upon the same track, and this is effected by placing a series of signals, visual or audible, at proper distances apart along the line of the railroad ; the minimum distance or interval of space between any two signals being equal to the minimum distance which is desired to maintain between the trains. Each signal is capable of giving two indications, one signifying " danger " and the other " safety."

In order to effect the result aimed at, it is necessary that each signal, when a train has passed it, should be made to take a position denoting " danger ; " that it should continue to give such indication until the train has passed over the space between that signal and the next signal in advance, after passing which latter the first signal is restored to a position denoting " safety." Thus each train, as it proceeds, is guarded by a danger signal, maintained at a distance behind it not less than the length of one signal section. This general system of protecting trains by signals is technically

known as the "block system" and originated in England many years ago.

The first mode of operating it, which is still in extensive use, was to place a signal-man at each signal, whose duty it is to exhibit the signals as required, and in accordance with directions communicated by telegraph from the adjacent stations. For example: when a train passes a given signal station, the signal-man, as soon as it has passed him, sets a danger signal; he then telegraphs to the next signal-man in the direction from which the train came, to withdraw *his* danger signal and to exhibit a safety signal. When in like manner he receives information from the next signal-station in advance, he changes his own signal from "danger" to "safety" in the same way.

Of course, if the engineer of a moving train encounters a signal indicating "danger" he is expected to stop until the indication changes to "safety."

The general plan of operating a series of signals in this manner is therefore old. The next step was to operate them *automatically* by the action of the train itself, and this is exemplified in Clark's patent of 1861 (Deft's Ex. 44), in which the weight of the train, as it passes a signal depresses a lever, and by mechanical device turns the signal to danger, where it is held by a latch, after the departure of the train. Upon the arrival of the train at the next station in the series, this operation is repeated, while at the same time the movement of this signal closes an electric circuit extending back to the first-mentioned signal, which acts upon an electro-magnet, which lifts the latch, and allows the signal to resume its safety position by the action of gravity. This apparatus required a special battery and an independent electric circuit for *each signal*. Each circuit was only closed momentarily, which was, however, long enough to release the detent which held the corresponding signal in a position of danger, and so allow the force of gravity or of a spring to restore it to its normal position of safety.

Another arrangement proposed was to make use of the elec-

tric current both to turn the signal to danger and safety. This is found in Johnson's patent, 1858. (Complainant's Ex. M, Exhibit Book, p. 21.) There we have each signal operated alternately by two electro-magnets, one to move it to "danger" and the other to "safety." Every train carried with it its own battery, which was applied to operate the signals in succession as the train reached them.

The next step was to operate the signals, both for danger and for safety, by stationary batteries, a method which is exemplified in Hall's system (Deft's Exhibit 4, and others), which he put in operation on the Harlem R. R. in 1871. This system required two distinct batteries to operate each separate signal. One battery for each signal would have sufficed, if he had made use of a circuit-closer operated by the train, capable of keeping the magnet in action long enough to bring the signal into its danger position. Not having such a circuit-closer until it was invented by Snow in January, 1873, he was obliged to employ what he called a double-circuit instrument, which is nothing more than a relay, provided with a locking detent. The momentary closure of the circuit by the circuit-closer then used (see Compt's Ex. D), although entirely too brief in duration to effect the movement of a signal disc through a perceptible distance, was sufficient to move the light and delicately adjusted lever of the double-circuit instrument through a distance sufficient to close the secondary circuit, which latter was then kept closed by the agency of the latch or detent acting upon the lever.

This arrangement necessitates the use of two independent batteries at each signal, and on a railroad line of any length the number of batteries required is great. For example: The system used on the Eastern R. R. prior to 1874 (Defendant's Ex. No. 36) employed three independent batteries for each pair of signals, consisting of a danger and safety signal, or six batteries per mile.

Thus the section of five miles, between Salem and Lynn, appears to have required no less than *thirty* independent batteries.

Now, as only one of the series of signals is required to be operated at a time, it would obviously effect an enormous saving in the cost of equipment and operation if one and the same battery could be employed to actuate each signal in succession, as wanted. The plan shown in Johnson's patent (Complainant's Exhibit M) does not accomplish this, because *every train* must be provided with a battery, and if the number of trains is large it would require as extensive an equipment of separate batteries as the Hall system, as above spoken of.

This problem was solved by Pope, in a simple and effective manner, by establishing two parallel conductors along the line of the railroad, connected with opposite poles of the same battery, so that a signal could be operated at any point from the one battery, simply by forming a connection from one conductor to the other by the action of the moving train on a proper circuit-closer; the electro-magnet for operating the signal was placed in a branch or cross circuit.

II.

WHEN WAS POPE'S INVENTION MADE?

His patent was dated July 1, 1873, and in the absence of any other evidence on the subject, either that time or May 15, 1873, the date of his application, might be taken as the date of his invention.

The defendant, however, claims that Hall made the same invention before either date, and we will therefore consider, first, what Pope did in relation to his combination, and, second, whether upon these facts he is to be regarded as the first inventor, according to the settled principles of law on that subject.

FIRST.

What did Pope do?

It is proved and not denied in the case, that in June, 1871, Pope, together with Messrs. Hendrickson and Ashley, formed a copartnership for the purpose of making and erecting electric signals on railroads, and from that time until some time in 1875 Mr. Pope was actively engaged in that business.

In the Summer and Fall of 1872 he was placing electric signals on the Pennsylvania Railroad, and about the first of November, 1872, he conceived the idea of this invention substantially as it was patented, and about the 6th of that month described it to Mr. Hendrickson in detail.

Mr. Hendrickson then and there made a diagram showing the operation of the invention, and showed it to Pope to see if it was correct, which diagram is put in evidence as complainant's Exhibit X. May 15, 1873, Mr. Pope filed his application for a patent for the invention, and it was issued July 1, 1873.

Two questions arise to be considered: *a.* Are these statements true? *b.* If so, is the invention shown in Exhibit X the same as that shown in the patent?

a. These facts are sworn to absolutely, by two witnesses, and are not contradicted by anyone. It is, moreover, perfectly probable and consistent.

If it is claimed that a person makes an invention relating to some matter with or about which he has no special connection or knowledge, a natural doubt may arise; but where the invention relates to the very subject about which he has been engaged for years, and in regard to which he is continually making and patenting improvements, and especially where the court can see the various facts, experiments, and circumstances which are connected with the invention, and can trace in them the processes of mind by which the inven-

tion gradually developed itself, in the absence of conflicting testimony it is impossible to doubt the truth of the statements.

On pages 48 to 54 of the Record, inclusive, Mr. Pope details the system of signals which he placed on the Pennsylvania Railroad in the summer of 1872, and states that he found in the practical operation of that system, that the violent mechanical shocks given to the moving parts of the signal machinery when the armature of the main magnet came in contact with the poles, caused it to get out of order, and he turned his attention to remedying this difficulty. In this system the signal remained exhibited by the residual magnetism holding the armature to the magnet until it was released by a neutralizing current passing through the branch circuit, and it was the strength of this magnet and the power with which it drew the armature to it, which caused these shocks.

To remedy this, as explained in Complainant's evidence, page 51, Pope attached a cut-off or circuit-breaker to the lever connecting the armature with the signal-disc, which cut-off so acted to interrupt the circuit through the main magnet before the armature came into actual contact with it, that, though the signal would swing into place by the momentum given to it by the movement of the armature, the shock of the armature striking against the magnet would be rendered almost imperceptible.

Cutting off this connection of course prevented the signal from being held in position by the residual magnetism of the main signal magnet, and to prevent its falling back a small armature was placed on the signal, which, just as the signal swung into place, was attracted by the poles of another magnet, which received, through the cut-off device, the current so cut off from the main magnet, and thus held the signal in place.

Before this it had been suggested to Pope by some officer of the railroad company that it might be well to have a secondary signal placed on the road some distance ahead, which would show the engineer that the primary signal had

performed its office properly, and while arranging the mechanism last named it occurred to Mr. Pope that this secondary signal might be included in the same circuit as the second or locking magnet, so that the same current which had been cut off from the main magnet, and had then gone to the independent magnet, would go still further and operate this secondary signal, so that two different signals would be worked *successively* by one battery. This was in September or October, 1872.

Here, apparently, is the first idea in Pope's mind of his invention, the object to be attained, and a suggestion of the way in which it might be obtained.

At the same time another application of this cut-off occurred to him, which was to use it to repeat the indication of a distant signal back over the same wire which conveyed the current to operate the signal.

These methods he prepared drawings and specifications for, and applied for a patent for one, October 24, 1872, and for the other, December 21, 1872.

These arrangements and combinations suggested to Pope at this time the further idea, being an extension of the same theory, that a series of signals might be worked by one battery by transferring the current from one signal to another, by means of a passing train instead of automatically. The use of a passing train to actuate signals was well known, but up to this time it had only been employed where one battery was used for each signal. The idea of a series of signals being worked in succession from one stationary battery, by a train passing along and working signal after signal by its passage, which is the essence of this invention, is thus shown to have been gradually brought out in Pope's mind by a succession of suggestions or ideas, one leading naturally to another, until he had the whole plan thought out in his brain.

Pope says, page 53:

"It was during the time we were at Sunbury and Northumberland, during the week prior to November 6, 1872, that I first described to Hendrickson a plan which I had conceived of working a series of signals along the line of a railroad in the manner we had been doing near Pittsburg, by the use of a single battery to operate the whole series. I cannot now state precisely when I conceived of this idea, but it was suggested to my mind by the device which I have already explained, whereby a primary and secondary signal were operated in succession from the same battery. As the signals in such a series are necessarily operated successively, and only one at a time, the suggestion occurred that the current of a single battery might be transferred from one to another as required, in something the same way as in the device already mentioned."

Mr. Hendrickson, on page 34 of Record, confirms Pope in this statement, and, moreover, states that he at the time made a drawing or diagram of the plan, which he preserved and puts in evidence as Exhibit X, and he states that he showed the diagram to Pope to be sure that he was correct. His testimony on this point is as follows:

"Int. 54. When and where did you first hear Mr. Pope speak of a plan for operating a series of electric block signals by means of a single battery and battery wires or conductors extended along the line of a railroad, substantially in the manner described in his patent, No. 140,536, complainant's Exhibit A?

"Ans. During the time I was at Sunbury and Bethlehem.

"Int. 55. Have you stated when you left Sunbury?

"Ans. I believe I have. About the 6th of November, 1872.

"Int. 56. Did he describe to you at that time fully or only partially, and did you make any diagram or memorandum of it?

"Ans. He described it fully, and in such a manner that I made a diagram of it, and showed it to him to know whether it was as he intended it.

"Int. 57. State whether or not this was done while you was at Sunbury or Bethlehem?

"Ans. It was done while we were at Bethlehem, or on the train going from Sunbury to Bethlehem.

"Int. 58. Have you that diagram now?
"Ans. I have. Here it is."

(Complainants offer diagram presented by witness, in evidence, which is marked Exhibit X.)

"Int. 59. State whether or not, after making this sketch, you showed it to Mr. Pope?
"Ans. I did."

This testimony, which is entirely uncontradicted, fixes the date of the invention by Pope as early as November 6, 1872, and shows that at that date it was so clearly conceived by him and disclosed to Hendrickson, as to enable the latter to make a drawing showing its operation. It is also clear that to have the invention so distinct in one's mind as to be able to put it in words, and so describe it to another person that *he* can make a drawing, shows much more fully the completeness of the invention than to make the drawing one's self.

It further appears from the evidence of Pope and Hendrickson, on the pages following those quoted, that this new plan so impressed the latter that he at once went to work to construct an improved signal to be worked by it, so made that it required a very slight electric power to operate it, thus enabling a larger number of signals to be worked from one battery, and he made a sketch of it (Complainant's Exhibit Y, Exhibit Book, between pages 58 and 59), which also shows Mr. Pope's invention, substantially as in the former drawing. This was a very rough sketch of the new signal, and a short time afterwards he made a more elaborate sketch, which only shows the signal part, but not the arrangement of wires, etc. This last drawing he showed to Pope December 3, 1872, and once was so much struck by it that a working model was at Pope ordered, and an application for a patent prepared and filed Dec. 26, 1872, and at the time Pope entered the date and Hendrickson's initials on the paper, as seen in Complainant's Exhibit Z, Exhibit Book, between pages 58 and 59.

Attention may be called at this point to the further important and material fact, apparently overlooked by the court below, that this was done by Pope's direction, and, such being the case, what Hendrickson did in pursuance of such direction enures to Pope's benefit, as regards any question of diligence, reduction to public use, etc., as completely as if Hendrickson had been an employee instead of a partner. The fact that Pope ordered it to be done, that Hendrickson did it, and that the doing of it was in the direction of the development and perfecting of the invention of itself establishes diligence.

On p. 55 of Record, Pope testifies that before the 10th of February, 1873, he had a conversation with A. G. Davis, the Superintendent of Telegraphs on the Baltimore & Ohio Railroad, in which he told him that he had devised a plan for working several signals with one battery, and afterwards put up a signal on that road to illustrate the practical working of the plan. Mr. Davis, on p. 132 of Record, confirms Mr. Pope in this, and says that the conversation was before the 1st of February, 1873.

Some time in April, 1873, Mr. Pope had a conversation with a Mr. McCracken, who said he was acting for the Harlem Railroad, in which Mr. Pope outlined the invention, and prepared and gave Mr. McCracken a sketch of it, a copy of which, made April 10 or 11, 1873, is introduced in Complainant's Exhibit C C, Exhibit Book, between pages 58 and 59.

From this evidence and the exhibits it is too clear for question that Mr. Pope did make this invention as early as November 6, 1872.

A comparison of these drawings, with the drawing annexed to Pope's patent, will show their substantial if not exact identity.

To facilitate this examination we have had prepared and placed in the brief opposite to this page, copies of the drawings, Exhibits X and Y, with letters on the different parts corresponding with the letters on the drawing annexed to Pope's patent, a copy of which drawing is also placed on the same page. A comparison of these will show better than any verbal argument can do, the identity of the invention shown in the drawings with that described in Pope's patent.

We find in such drawings the battery B in combination with the positive and negative conductors C and Z, two electro-magnets, M and M, and two circuit closers *a* and *a*, also the magnets *m* and *m*, and the wires necessary for opening and closing the circuits.

Exhibit X, though roughly drawn, and not carefully finished, will be seen at once to be the same in substance as the drawing in Pope's patent, and Exhibit Y is perhaps still more distinct.

But it is not necessary that to show the date of invention the drawing should be sufficiently finished and clear to show the operation of the apparatus to every one. It is enough if there is sufficient in the drawing to enable a person skilled in the art to put the invention into practical use from it. This is the rule laid down in Loom Co. *vs.* Higgins, 105 U. S., p. 585.

Pope explained his invention to Hendrickson, who was a practical electrician, and he, from that description, prepared this drawing, for the very purpose of showing the manner in which it worked. There could be no better evidence that a drawing shows the manner of working an invention to one skilled in the art, than that such a person made it for that very purpose.

The answer of Mr. Farmer, who is a practical electrician, to Int. 12, p. 115 of Record, shows this:

Comparison of Diagrams. Exhibits A, X and Y.

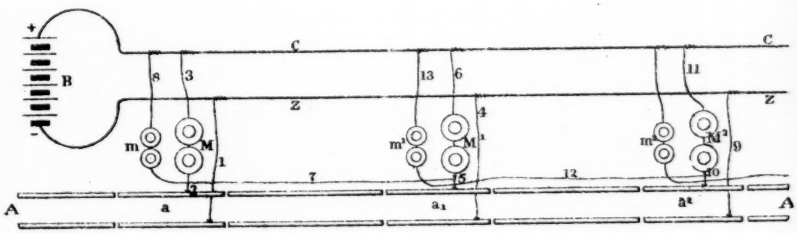


Diagram of Circuits. Ex. A

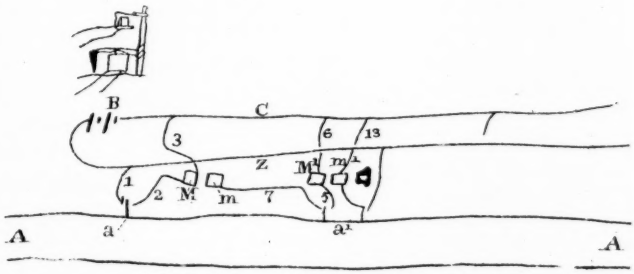


Diagram of Circuits, Ex. X.

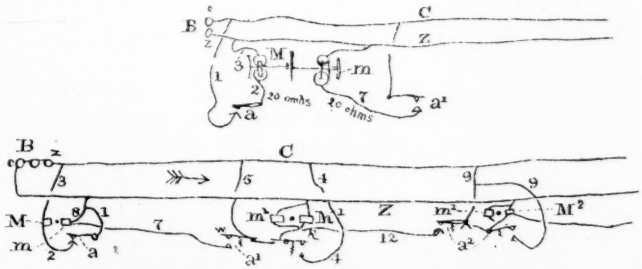


Diagram of Circuits, Ex. Y.

"Int. 12. Look at the sketch which I now hand you, marked Complainant's Exhibit X, and state in detail whether or not it clearly shows each and all of the material features of the combinations described in the complainant's patent, Exhibit A, and claimed in the several claims thereof.

Ans. I find that it shows the equivalent of the battery B, a positive and negative conductor C and Z, two (spelt *to*) electro-magnets actuating or causing to be actuated visible or audible signals, and two or more circuit closers placed at intervals along the line of the railroad. I find also the combination of the battery B, conductors C and Z, circuit closer A, and electro-magnet for actuating a visible or audible signal with a circuit closer, wires, and electro-magnet for reversing, releasing, or stopping said signal."

In answer to the next two interrogatories he says he finds the same combinations in Exhibits Y and C C.

If Pope, in November, 1872, had made a drawing just like that annexed to his patent, it would clearly have been sufficient to fix his invention as made at that date, and if the drawings then made show the essential elements of the combination, as Mr. Farmer says they do, it seems to us clear that the latter drawings come within the rule laid down in Loom Co. *vs.* Higgins.

There is no evidence introduced by the defendants to contradict this testimony, or to show that Exhibit X is not such a drawing as sufficiently shows the invention.

It may, however, be claimed by the defendants that this case is not like Loom Co. *vs.* Higgins, because in that case Webster, the inventor, himself made the drawing, and here the drawings in question were not made by Pope himself, but by Hendrickson from a verbal statement of the invention made by Pope to him.

But we submit that it is a much clearer proof of an actual, clearly defined, finished invention, where an inventor has it so clearly defined in his own mind, that he can and does state it

in words to another so clearly that such other, knowing nothing of the subject before, is enabled from these words alone to make a drawing clearly showing the invention, than if he makes the drawing himself.

It was early held by this court that a *verbal* description of an invention was legitimate evidence that the invention was then made.

In Phila. R. R. *vs.* Stimson, 14 Peters, 448, the defendant offered evidence to show invention prior to the date of the plaintiff's application, and the plaintiff, to show the date of his invention, offered to show, by certain witnesses, that at a date prior to that testified to by the defendant's witnesses, he had *verbally* described the invention to them as it was afterwards patented. This evidence was admitted in the court below, and its admittance was made the ground of exception. The court say on this subject, p. 462:

"His conversations and declarations, stating that he had made an invention, and describing its details, and explaining its operations, are properly to be deemed an asserting of his rights as an inventor to the extent of the facts and details which he then makes known, though not of their existence at an antecedent time. In short, such conversation and declarations, coupled with a description of the nature and objects of the invention are to be deemed a part of the *resgesta*, and legitimate evidence that the invention was then known to and claimed by him, *and thus its origin may be fixed at least as early as that period.*"

According to this case the verbal description to Hendrickson, if clearly proved, would have been sufficient, without any drawing, but in the case at bar we have also the fact that drawings were made in pursuance of the verbal description, and clearly showing the invention.

The object of the patent law is to ensure the giving of an invention to the public. So long as it remains solely in the mind of the inventor it is concealed from every one else, but

when he describes it to some other person who makes drawings of it from that description, it goes away from the inventor, and unless he obtains a patent for it, it is imparted to the public. It is reasonable, therefore, that such communication should be considered as the date of the invention, and that the patent when granted should protect the inventor against any one who discovered the same thing after him.

If, then, this court is satisfied that Pope did before November 6, 1872, make the invention described in his patent, and that the drawings, Exhibits X, Y, and C C, were made as claimed; upon the principles laid down in Loom Co. *vs.* Higgins, the court below was in error, for it is not claimed that Hall made his invention and described it to any one before December 21, 1872, and the plaintiff is entitled to judgment so far as the question of prior invention is concerned.

SECOND.

According to the settled rules of law on this subject, these facts show that Pope's invention was made at least as early as November 6, 1872.

It is not necessary for us here to discuss the general subject of when inventions are made, it is enough to show, that the time of making a drawing showing the invention, of such a character that a person skilled in the manufacture of that kind of apparatus could, from an examination of the drawing, put the invention into practical operation, will be taken as the date of the invention.

It seems to us that the law upon this subject has been so lately settled in the case of Loom Co. *vs.* Higgins, 105 U. S., p. 580, as to render it unnecessary to discuss it at length.

In that case the principal question was, whether one William Webster, who obtained a patent for a certain improve-

ment in looms, dated August 27, 1872, was the first inventor of the improvement therein described. The defendants, in the year 1871, made a loom containing Webster's invention (p. 593).

It was claimed by the plaintiffs that the date of the drawing was the date of the invention, and the court so held.

Mr. Justice Bradley says on p. 592, and subsequent pages:

"The next contention of the defendant's which we shall consider, is their allegation that Webster was not the first and original inventor of the thing patented, but that he was anticipated therein by E. K. Davis.

"On this point we think it is very clearly made out, though we shall not go into much detail in commenting upon the evidence, that the whole substance of the invention was conceived by Webster, *and exhibited by him in a drawing* as early as the winter of 1865–66, long before Davis entertained any idea of it. The original of this drawing is in existence and was produced in evidence, and is well authenticated. (Then on p. 594.) Conceding that Davis was an original inventor, the earliest point of time that he can be regarded as such was in the spring of 1868. But Webster had invented it before that time, and had made a drawing of it, which in March, 1868, he exhibited and explained to Davis. An invention relating to machinery may be exhibited *either in a drawing* or a model, so as to lay the foundation of a claim to priority, if it be sufficiently plain to enable those skilled in the art to understand it."

This is not a new principle, as it had before been authoritatively decided in the circuit courts in many cases.

In Reeves *vs.* Keystone Bridge Co., 5 Fisher, 456, McKennan, J., says on p. 462:

"A patentee whose patent is assailed on the ground of novelty may show by sketches and drawings the date of his inceptive invention, and if he has exercised reasonable diligence in perfecting and adapting it, and applying for a patent, its protection will be carried back to such date."

In Kneeland *vs.* Sheriff, 2 Fed. Rep., p. 901, a similar decision was made.

In Draper *vs.* Potomska Mills, 13 Official Gazette, p. 276, Shepley, J., says:

"But a patentee whose patent is assailed upon the ground of novelty may show by sketches and drawings the date of his inceptive invention."

These cases, and many others that might be cited, establish the rule that in the case of a patentee whose patent is attacked by proof of an invention prior to the date of his application, if he shows that before such prior invention he had himself conceived a clear, distinct, and complete idea of the invention, and had made a drawing of it, from which a person skilled in the art could have put the invention into practical operation, the protection of the patent will go back to the time of his making such drawing, though such patentee had never made a practical use of his invention.

We limit this rule to the case of a patentee whose patent is attacked by proof of prior invention, because the cases make a distinction between the required proof to be given by an inventor who has obtained a patent, of the time of his invention, and that required to defeat a patent actually issued, by showing an invention prior to the date of such patent by a person who claims to be a prior inventor.

In Union Co. *vs.* Matherson, 3 Fisher, p. 600, Mr. Justice Clifford says:

"*Settled rule is*, that it is not enough *to defeat a patent already issued*, that another previously conceived the possibility of effecting what the patentee has accomplished, unless it also appears that he reduced what he conceived to practice in the form of an operative machine."

Many *vs.* Jagger, 1 Blatch., 383.
Parkhunt *vs.* Kingsman, 1 Blatch., 494.
Cahoon *vs.* Ring, 1 Fisher, 408.
Cox *vs.* Greggs, 2 Fisher, 174.
Johnson *vs.* Root, 2 Fisher, 291.
Johnson *vs.* McCullough, 4 Fisher, 170.
Parker *vs.* Stowe, 14 O. G., 560.
Coffin *vs.* Ogden, 18 Wall., 120.
Kelleher *vs.* Darling, 14 O. G., 676.

We submit that both in fact and in law the case at bar comes clearly within the case of Loom Co. *vs.* Higgins, which was decided after the decision in this case; and that the evidence in this case shows that Pope was the first inventor of the combination claimed in his patent.

THIRD.

But the defendant further claims in this case, that even granting that Pope did have these drawings made as claimed, and in the absence of any other evidence in the case would have been the first inventor, yet that Thomas S. Hall either in January or April, 1873, and before the date of Pope's application, made the same invention, *and put it into practical use on a railroad*, and that, therefore, in the eye of the law, thought not in fact, Hall is entitled to be considered as making the invention before Pope, so as to invalidate Pope's patent.

This, as we understand it, is the ground upon which the court below decided this case against the plaintiffs. He says in his opinion on page 299 of the Record:

"The patent having been granted to Pope, and now being attacked on the ground that the patentee was not the first inventor, it is not enough for the defendant to show that Hall had conceived the same idea, and had made drawings or models, and experiments with his models, but the defendant must establish that Hall reduced what he conceived to practice, and embodied it in some practical and useful form, before Pope made his application, it being a fact in the case that Pope had not *reduced his idea to practice* before his application."

And again on p. 302 Record.

"Pope first achieved a mental result. After that he was actively occupied in the same branch of study, but he did not develop this system *in wood and metal.* Hall did develop it, made it useful and practicable, and achieved success."

The principle laid down here by Judge Shipman is this: If a person invents a machine, and makes a drawing of it clearly showing its construction and mode of operation, but does not make an *operative machine*, and another person after the first has made such drawing, but before he applies for a patent, also invents it and *does* make an operative machine, the latter is the inventor, and entitled to a patent, unless the former in the meantime was steadily engaged in perfecting his invention so that he might make an operative machine.

We have had some doubt in considering this part of the opinion what the exact ground is upon which it is based.

If the learned judge considered that the drawings X, Y, and C C, did not sufficiently show the invention, he does not say so, nor base his opinion on that ground. From some of the expressions used by him, however, it would seem that he threw out of the case entirely everything done by Pope before the date of his application, and based his decision on another principle, viz.: that to defeat a patent, it must be shown that a prior inventor had made an *operative machine in wood and metal* before Pope made his invention. This principle we do not attack, but such are not the facts in this case, and after a careful examination of the whole opinion, it seems to us that upon the facts which the judge finds, he is governed by the principle which we have before stated.

See Merwin on Patentability of Inventions, p. 692.

If, however, we are wrong in this, what we proceed to say upon this question of law may be immaterial, but what we say upon the question of fact, as to what Hall did in April 1873, will become more material.

FIRST.

Let us first then examine this claim as to the law, for if it is unfounded it is unnecessary for the court to spend time in considering what Hall actually did. The learned judge, to

sustain this view of the law, cites one case in this court, and five upon the circuit.

The first is Agawam Co. *vs.* Jordon, 7 Wall., 583. The question in that case was solely whether Goulding or Winslow was the actual first inventor of the machine patented. No question arose as to whether after Goulding made the invention, and before he made his application, Winslow, or any one else first put the invention into *practical use in wood and metal*, nor were there any facts upon which such a question could arise. The court on page 602 does say, "He is the inventor and is entitled to the patent who first brought the machine to perfection, and made it capable of useful operation," but neither that general statement nor anything else in the case warrants Judge Shipman's conclusion. The case was decided upon the ground that Goulding was actually the first inventor.

The case of Ellithorpe *vs.* Robertson, 2 Fisher, 85, was a case of evidence offered to *defeat* a patent already granted by proof of prior invention by another, before the date of the patent, and it was held, as it has been in many cases, that in such a case it was not enough to show that some one else had conceived the invention, it must be embodied in some practical and useful form.

The other cases cited, viz.: Union Sugar Refinery *vs.* Mathieson, 3 Cliff., 639; White *vs.* Allen, 2 Fisher, 440, and Read *vs.* Cutter, 1 Story, 590, were all cases of a like character. In all of them the court was speaking of what sort of invention was required to *defeat* a patent, not to *sustain* it. In none of them had the patentee shown his invention by drawings or otherwise, at some date before his application, and a subsequent invention and reduction to *practical use in wood and metal* between that date and the application, been held to be a prior invention to that of the patentee. We believe the case at bar to be the first one which enunciates such a principle as applied to such facts, and it seems to us that if the case of Loom Co. *vs.* Higgins, had been decided before

Judge Shipman decided this case, he could not have fallen into this error, for in that case the facts were precisely similar to this. There Webster made his drawing in 1865. Davis made a loom, embodying the same invention "in wood and metal" in 1870–1, and the patent was not issued to Webster until 1872. No such claim as is suggested here seems to have been thought of by Mr. Gifford or Mr. Evarts the counsel for the defendants, nor is any such view of the law hinted at by the court. Nor would such a claim be consistent with the principles laid down in that case, and many others. It has always been held that a person, who has obtained a patent, when it is attacked by proof of a prior invention, can go back to the time of his invention and show by a drawing made before the date of such prior invention when the real time of his invention was claimed. And the courts have always held that if he could do so, he was the inventor at that time, and consequently the first inventor.

If Webster was the *first inventor* when he made his drawing in 1865, as the court in the Loom case held he was, how could he be deprived of that position by the fact that a *subsequent* inventor first made a loom "in wood and metal." How could a *later* inventor be the *first* inventor? It is a contradiction in terms. Can one be the first inventor *in fact*, and another one the first inventor *in law?*

The error of the learned Judge below, it seems to us, was in considering that when the judges to whom he referred, spoke of he being the inventor "who first brought the machine to perfection and made it capable of useful operation," or as Judge Clifford says in Agawam Co. *vs.* Jordon, "who first reduces his invention to a fixed, positive and practical form," etc., they meant necessarily an "embodiment in wood and metal."

What they are speaking about is not reducing the invention to *actual use* in a full-sized machine, by an inventor, but reducing vague or indefinite ideas into a perfected and finished

invention *ready and fitted to work*, or a general idea into a practical form. A practical form of a machine may be shown by a drawing as well as by the machine itself.

So in Seymour *vs.* Osborne, 11 Wallace, p. 552, the court says:

"He is the first inventor in the sense of the patent law and entitled to a patent for his invention who first *perfected and adapted* the same for use, and it is well-settled that until it is so perfected and adapted for use, it is not patentable under the patent laws."

The court do not say when the invention is *actually used*, but when it is *adapted for use*: when it is all ready to be patented, when *invention* is finished, and all that remains is to make the application.

So, to apply this principle to this case, if Pope had only had the idea that it would be very desirable to have one battery operate several signals instead of having one battery for each signal, and that in some general way it could be done, he could not have patented that idea, but as soon as he had thought out and invented a practical method of so using one battery, had adapted it for use in a drawing or model which showed exactly how it was to be used, or an application, he had reduced his idea to practice and embodied it in a *distinct form*. Every element of his combination was old, and as well known to a practical electrician as A, B, C. It was as clear that each part would operate, when shown in the drawing, as if it had been used a dozen times.

This distinction appears clearly from other cases.

In 1851, Judge Nelson in Pitts *vs.* Hall, 2 Blatchford, p. 271, says:

"The question as to who is the first inventor *is not who constructed the first machine* but who conceived and *gave practical form and effect* to the arrangement which constitutes the improvement."

So Judge McLean in Allen *vs.* Huntoon, 6 McLean, 322, says:

"If both plaintiff and defendant are inventors of the thing claimed by them respectively, the one who *perfected his invention first* is protected by the law. A general remark that he had accomplished his object, without particularizing what he had invented or discovered, is not satisfactory, but a statement of the thing invented or discovered should be considered as evidence so far as it agrees with the patent subsequently obtained."

"It is not necessary that an inventor shall reduce his invention *to practical use* before the patent is obtained. It is enough that the inventor *has perfected his invention, and is able to furnish the Patent Office such specification and model as the law requires.*"

Wheeler *vs.* Clipper Co., Woodruff, J., 6 Fisher, p. 1.

It may be desirable to say something on another point mentioned by the court below, viz.: as to whether Pope used due diligence in *perfecting his invention.* On p. 302 of Record the court says in its opinion:

"The just and equitable principle of the law which gives a patent to the inventor who first conceives of the invention, provided he is diligently engaged *in perfecting it and adapting it to use*, and overcoming the practical difficulties which are always to be surmounted before theory becomes fact, although he was slower in the race than the one who was second to conceive, do not apply to Pope."

A distinction is to be noted here between diligence in applying for a patent, and diligence in *adapting the invention to use.*

There is no limitation as to the time for applying for a patent, unless the delay is so great as to raise a presumption of abandonment. The principle referred to only applies to the case of an inventor who has partially made an invention, but still needs to add something in order to make the invention successful. If his invention is complete, there can be no perfecting. We think one error of the court below was in not noticing this distinction.

The invention of Pope was as complete when the drawing was made in 1872, as it was when the patent was issued.

All the parts of the combination were perfectly familiar to him, as well as their modes of working. None of them needed to be tried, nor did the invention itself need to be tried to prove to one skilled in the art that it would work successfully; the erection of an apparatus on a railroad would not have shown him anything about its operation which he did not know before. This appears from the fact that the first drawing is substantially like that annexed to the patent.

The only ground for such a claim is that Hall, when he first tried to operate it, found that to make it work satisfactorily it would be necessary to equalize the resistance of the different circuits.

Snow, who testified on this point, after stating that the magnets they first used, being wound with too coarse wire, required so much battery power to work them, that on the long circuits the electric current destroyed the points of the circuit-closers, says on p. 175:

"This difficulty showed that it would be necessary to equalize the resistance of the different circuits belonging to the different signals."

The only way that he or Hall knew of or tried, to remedy this difficulty was, to bring the earth into the circuit.

But this question of resistance was familiar to Pope, for in the specification of his patent he says:

"The respective resistances of the different circuits should be so adjusted that they will be as nearly as possible equal to each other, as a much more perfect action of the apparatus will be secured thereby."

This was a mere matter of computation and adjustment, as Mr. Pope says on page 57:

"It was a very easy matter for any competent electrician to calculate from existing data the amount of battery power, the size of conductors *and the proportionate electrical resistance of the different parts*, so as to insure the satisfactory operation of the system in practice."

It was nothing more than it would be in building a bridge to determine the size and proportion of the different timbers to enable the bridge to bear the necessary strain.

So Mr. Farmer on p. 18 of the Record says:

"There are many well-known methods of adjusting these resistances, such as varying the dimensions of the wire on the magnets *m* and M; likewise the resistances of the branch wires 3 and 6, 8 and 13, 7 and 12, etc., may be so varied as to secure this equality of resistance."

As therefore there was nothing needed to perfect the invention or adapt it to use, there could be no question of whether due diligence was used by Pope in perfecting or adapting it.

If these views of the law are correct, there can be no necessity for an examination of the evidence to see whether Hall did in fact use the invention between November, 1872, and May, 1873, but as it may be made a question in the case, we will consider it briefly.

II.

Did Thomas S. Hall put this invention into actual use before the date of Pope's application?

Some time in January, 1873, his son made an arrangement of wires upon the walls of Hall's work-shop in Meriden, which he claims showed the invention, but, as we have shown, that is not sufficient to defeat a patent actually granted, there must be an actual *use* of the invention for the purpose for which it was intended.

Hall claims he did do this some time in April, 1873.

To determine this we must first see what the real invention was, and then see what Hall did.

FIRST.

The invention as stated in the patent is a "peculiar arrangement of electric circuits in connection with a battery and with *two or more circuit-closers* operated by moving trains or otherwise, whereby a series of *two or more visual signals, situated at intervals along the line of a railroad*, may be operated by currents of electricity derived from a single battery, thereby obviating the inconvenience and expense of employing one or more separate batteries, situated at or near *each signal* for the purpose of actuating the same."

It was no new thing to use *one battery* and *one track circuit-closer* to operate one signal by passing trains. This had been done before by Hall, by Pope, and by many others, and was well known.

The point of Pope's invention was to improve on this well-known practice by having one battery operate *two or more signals through two or more circuit-closers each of which circuit-closers* should be connected with, and should operate its appropriate signal, both circuit-closers and signals being "situated at intervals along the line of the railroad."

The operation and use of the invention described in the patent required that when a train passing along the road reached one track circuit-closer, one signal of danger was displayed and remained so until the train reached a second track circuit-closer, when the signal of danger connected with that second one was displayed, and at the same time the signal attached to the first one was changed from "danger" to "safety."

It is obvious that there was *no possible way* in which only *one* track circuit-closer on a track, connected with one or more signals could show the invention in *actual use*. Until a method is discovered of placing *one* track circuit-closer "at intervals along the track" it cannot be done; it is absolutely necessary, to show this invention of Pope's in actual use, to have at least two track circuit-closers, with a separate signal connected with each.

The combinations referred to in the claims of the patent also require this, for they all specify two or more circuit-closers placed at intervals along the line of the railroad.

This seems so apparent, that it would have seemed to us unnecessary to argue it at such length if the court below had not held otherwise.

SECOND.

But it is equally clear that so far as any actual use of any part of the apparatus claimed in Pope's patent was concerned, Hall before the date of Pope's patent never used but *one track circuit-closer and a single signal* actuated by or through it. All of the defendant's witnesses who testified on this point agree to that.

It must be agreed that all that Hall did in December, 1872, was to put up a model on the walls of his work-shop in Meriden, showing the necessary arrangement of wires, which was nothing more than a drawing or verbal description would have been.

The only actual use claimed by the defendants, or referred to by the court below, was that in April, 1873.

Complainant's Exhibit L (Book of Exhibits facing page 20), which was made by Mr. T. S. Hall, himself (as appears from

p. 237, Record), for the very purpose of showing all that was done at this claimed use of the invention in April, 1873, shows only *one* track circuit-closer on the line of the railroad.

All the witnesses for the defendant who testify on this point agree, that in the experiment in April, 1873, only one track circuit-closer was placed on the line of the railroad.

The first mention of it was made by Alvah W. Hall, in his answer to cross-Int. 80, p. 163 of Record. After saying that the circuit-closers used in the model placed on the wall of the shop at Meriden were "hand circuit-closers" he says:

"These circuit-closers were placed for convenience on the walls of the shop of my father instead of placing the large sized circuit-closers in the building. In fact one of these circuit closing points marked Y in Exhibits Nos. 5 and 6 was connected with *a track circuit-closer* situated on the down track of the N. Y., N. H. & H. R. R. at a point an eighth of mile from the building, wires having been run on telegraph poles from this building to the railroad; and all down trains on said road would close *the circuit-closer placed in proximity to the rail*, causing a circuit to be completed from battery X by wires A and A 1 to *circuit closer* placed in proximity to the railroad (by a wire provided for that purpose), through *that circuit*-closer, to an electric-magnet Z by a wire provided for that purpose, and wire *b*1 of double circuit instrument No. 1 through said magnet by wires B1 and B. In fact the circuit-closing point of double circuit magnet Z of double circuit instrument No. 1 was removed to *a point* on the line of said railroad by prolongation of wires A1 and *b*1. *The balance of the circuit-closers* were what we term hand circuit-closers, intended to *illustrate* the closing of circuits by trains operating upon their proper circuit-closers."

See also Re-direct Int. 91, p. 167.

"Re-direct Int. 91. In your answer to Int. 10, you stated that *no signals were operated* from the apparatus you put up in the shop at Meriden in the winter of 1872–3 described in Exhibits Nos. 5 and 6. State whether subsequently to that time you made any use of such apparatus at your shop, in connection with any railroad track for actuating automatic signals.

"Ans. Yes, sir.

"Re-direct Int. 92. When and how?

"Ans. In March or April, 1873. The manner of the application is described in my answer to cross-Int. 80, to which I therefore refer you in order to avoid unnecessary repetition. I will add however to what is therein contained, that in connection with *this track circuit-closer* therein mentioned *the visual signal* as shown in Exhibit G was substituted in the place of one of the five double circuit instruments which were in the circuit of battery X as shown in Exhibit C."

This testimony shows plainly that only *one track circuit-closer* was placed on the railroad track in April, 1873, and it was used to operate only *one visual signal* in the work-room. All the other circuit-closers used were *hand* circuit-closers on the walls of the work-room, placed there only to *illustrate* what it was supposed *could* have been done by placing other track circuit-closers on the track. Nor was this visual signal on or near the railroad track where it could be *used*. It was only in a room of the shop.

The testimony of George H. Snow is, if possible still more definite on this point. He says in answer to cross-questions 66 and 67 p. 186 of Record as follows:

"Cross-Int. 66. When was the construction of the *first* track circuit-closer which was practically adapted to the purpose of working a number of signals from one battery, commenced by you or others in the employ of the company represented by Thomas S. Hall?

"Ans. *The first track machine* of the kind which was *practically used* in working a number of signals from one battery was commenced by myself in the shop in New Haven prior to moving the shop to Meriden in 1873.

"Cross-Int. 67. *When did you first make a practical test of its working?*

"Ans. Soon after moving to Meriden, some time the latter part of April, 1873. *I placed one* on the track of the Hartford & N. H. R. R. and connected wires to it leading to the shop, and the wires were connected to *a battery and signal* so that passing trains would operate *the signal*. This machine was afterwards used for operating crossing signals on the same railroad."

So on page 190 of Record he is re-examined by the defendants counsel.

"Re. E. 101. Do you recollect when *the first* improved track circuit-closer was *actually applied* to a railroad in connection with a number of double circuit instruments designed to operate a number of signals from one battery?

"Ans. The improved track circuit-closer was applied to railroad track in the latter half of April, 1873; *there being only the one it could not be used to raise and reverse a number of signals automatically*, but it was connected to *a signal* sometime, so that a passing train would raise *a signal* and at other time reverse it."

It is impossible to express more clearly than this, the fact that but *one* track circuit-closer was actually placed on the track of the railroad in April, 1873, and that consequently *it was impossible by that apparatus to raise and reverse a number of signals in succession*, in the manner required to show the invention of Pope in actual use.

It seems to us moreover, that this experiment was not and could not have been intended to show such a practical use of this invention. It was only done by Mr. Snow as an experimental use of *his new track circuit-closer*, which was a new invention of Snow's, and for which he afterwards obtained a patent. This also appears from the testimony of Thomas S. Hall himself. On p. 224 Record he says in part of a long statement in his direct examination:

"We perfected the *first* improved atmospheric or air cushion circuit-closer, *and put the same in practical operation* in connection with the reverse magnet of the double circuit instrument of one of our crossing signals, on the down track of the Hartford & New Haven R. R. at Meriden, Conn., April, 1863. The first air cushion track circuit-closer was made by hand with such machinery as we then had in our shop. *As soon as its practical utility had been perfectly established* I commenced to make a complete set of tools especially to manufacture these atmospheric track circuit-closers. *This occupied quite a period of time.*"

Upon cross-examination on this subject he said p. 235 of Record:

"Cross-int. 23. In your testimony, p. 129 defendant's printed testimony (which is p. 224 of this Record) you speak of placing an air cushion circuit-closer on the track of the Hartford & New Haven Railroad Company. Is this the same placing spoken of by G. H. Snow in his answer to cross-int. 67, on page 68, defendant's printed testimony?

"Ans. It is the same track instrument. At the time mentioned by Mr. Snow he connected it *for one day* with the wires that we had erected on telegraph poles leading to our shop, and connecting with our improved signal system that we had there in our shop at that time. *During this experiment on the day mentioned I kept a man at the railroad crossing for the purpose of reversing the signals by hand*, that the down trains would put in operation after they had passed the crossing. We connected the wires that afternoon with *the* track instrument, and I had wires extending to *it*, and branch wires connected therewith in such a way that I could at any time make a change by disconnecting *this* track-circuit closing instrument from the crossing signals, and connect my branch wires to the main wires leading into our model-room. This arrangement continued until *I had finished a second* atmospheric track instrument, when I placed it at a point in the down track a few rods above the first one, and connected it directly with the wires leading to our signal instruments and battery in our model-room."

This last-named instrument remained in its position for at least six months.

Cross-int. 24. Have you any means of fixing the date of so first connecting the *first* atmospheric track circuit-closer mentioned, with the wires in the model-room more definitely than Mr. Snow has done?

"Ans. I think I have. I am strongly impressed that I have a letter from the man who had charge of the signals on the Hartford & New Haven Railroad, in which he states that it was the 22d day of April that it was done."

It is not necessary here, to consider whether before April, 1873, Thomas S. Hall had invented substantially the same combination as that which Pope invented in November, 1872,

nor whether he erected wires and what represented signals on the walls of his work-room which was substantially a model of his arrangement. That is not the question here. It is whether the invention of Pope was put *into actual use* by Hall before Pope's application was filed. The fact was that, so far as Pope and Hall were concerned, neither of them attempted to put the plan which had occurred to them into use, to see if it would work. Each of them were familiar enough with electrical signal apparatus to see at once that it ought to work. Pope had his idea represented by a drawing, and Hall had his represented by a combination of wires and other apparatus, arranged to show his idea. The principal difference between them were, that Pope had already invented a track circuit-closer and signal such as was necessary for the actual use of the invention, while Hall had not. Such a track circuit-closer and signal was not a part of the invention, but it was necessary to operate the invention in the best manner, and therefore it was that Snow went to work to make his new track circuit-closer, and in April, 1873, to try it on the track to see if it would work satisfactorily, and when they found it did, in April, 1883, they went to work, not to make another one of them and put that also on the track to test the invention by practical use, but to make the tools necessary for making a large number of them, which occupied a long time after April, 1873, so at that time there *could not possibly have been* two track circuit closers placed on the track, because Hall *only had one*. There was also this difference, that Pope knew all about the proper methods of equalizing the resistances while Hall and Snow did not.

It may be considered therefore as settled, that all that Hall did showing the actual use of his invention, before Pope's application for his patent, was to put *one* track circuit-closer on the railroad track, and connect it with one signal, so that a passing train would raise the signal. It is true that that signal was so connected with another signal as to operate that, but that was no part of the invention of Pope or connected

with it in any way; whether one track circuit-closer moved one signal, or a dozen signals arranged in a row, so connected that raising one would raise the rest, was no part or use of Pope's invention.

This more clearly appears if the court will consider, that to-day any railroad company can do all that Hall did in April, 1873, without infringing Pope's invention! It can put one track circuit-closer on its track, connect it with a series of wires and magnets just like Hall's, and erect one or a dozen signals on the line of its road, *all actuated at the same time*, just as Hall did in his room, but unless they put *another* track circuit-closer in another place on the track, and another signal independent of the first one to be moved by the second track circuit-closer, they do not infringe.

If, however, it were possible to conceive that one track circuit-closer and one signal as used by Hall could show Pope's invention in actual use, then it is in evidence that in March, 1873, the same thing was erected by Pope.

On page 55 of Record, Pope states that February 10, 1873, he had a conversation with a Mr. Davis, superintendent of telegraphs of the Baltimore & Ohio Railroad Co., about erecting his signals on that road, in which Pope explained this new plan to him, and he says: "we afterwards put up a signal on this road in Baltimore in order to illustrate its practical operation."

On page 103 of Record, on the cross-examination Pope further says, that "after explaining the one-battery system to Mr. Davis, either he or some other one of the officials requested us to put up one signal as a sample of the system, and the signal was put up in compliance with that request," and he further says that this was in March, 1873.

On page 132 of Record, Mr. Davis states that this signal was put up in March, 1873, and was so put up by Pope's direc-

tions to show the working of the one-battery system which Pope had before explained to him. There was a track circuit-closer, or breaker as he calls it, two wires on poles, two magnets and a signal, all put up to show, so far as one signal could, the operation of the one-battery plan. It was practically used, and trains were run by it for some time.

We do not refer to this to show that it was an actual use of Pope's invention. It was not and could not be of itself as we have already shown; but taken in connection with the verbal explanations and drawings which Mr. Davis says were made by Pope, it sufficiently showed the working of the plan for Davis to comprehend it. We refer to it *only* to show that it contained the same elements, and more, than those that Hall afterwards used in April, viz.: a circuit-closer placed on the railroad and worked by passing trains, a signal placed by the railroad, connected with a magnet, and two conductors or wires arranged according to Pope's one-battery plan. This certainly was all that Hall had in actual use in April, and was a month before, and was used as a signal system on a railroad.

There is another claim which can be made as to the sufficiency of what Hall did.

The decisions show that the *use* spoken of in cases like this must be *an actual use for the purposes for which the invention was made*, and not a mere working model.

The latter would be enough where the question arises between two inventors, each applying for a patent; but when one of the inventors has had a patent granted to him, to defeat it, there must be such a use as is above stated.

In Calhoun *vs.* King, 1 Fisher, 408, Judge Clifford says:

"Unless it appears to your satisfaction that such machine *was actually used as a seed-sower in sowing seed for agricultural purposes*, you are warranted in presuming that it was a mere experiment."

In Cox *vs.* Griggs, 2 Fisher, 174, Judge Drummond held, that making a working model was not sufficient, saying:

"It is necessary, in order to prevent a man from having the benefit of his patent, that another person should have first discovered the thing, and reduced it to *actual practice*."

In Union Sugar Co. *vs.* Mathieson, 2 Fisher, 600, Judge Clifford held, that to defeat a patent for certain machinery for cleaning sugar, it was necessary to prove that some other person, before the invention of the patentee, had actually used such machine *in cleaning sugar*.

In Johnson *vs.* McCullough, 4 Fisher, 170, Judge Giles held that in such a case making a working model was not enough, a practical working machine must be made.

In Coffin *vs.* Ogden, 18 Wallace, 120, the same rule is applied. That was a case where an inventor had obtained a patent for a lock, and it was claimed that one Erbe had invented it before him. In the opinion stress is laid on the fact that the lock had actually been used on a door, and the court says on page 125:

"The lock was put in use, being applied to a door as proved by Brossi. *It was thus tested and shown to be successful.*"

Now under these decisions what Hall did was not a *practical use* of any invention. No signal was placed on the track of a railroad so that it was practically used, no trains were or could be run by it. Putting up wires and one signal *in his shop* could, at the most, be only a model, and whether the model was worked by a track circuit-closer an eighth of a mile off, or by a hand circuit-closer in the shop, made it neither more nor less than a model. It was an actual practical use of the new track circuit-closer, and of nothing more, and it would have been the same if he had two track circuit-closers on the railroad track, and two signals in his shop.

This further appears from the fact that the connection between the track circuit-closer on the track and the signal in the shop was not even such as would cause the passage of a following train to reverse a signal when it had been actuated by a former train. Hall himself says, page 235 of Record:

"During this *experiment*, on the day mentioned, I kept a man at the railroad crossing for the purpose of *reversing the signals by hand* that the down trains would put in operation after they had passed the crossing."

We submit, therefore, that it very clearly appears from these facts, which are not controverted, that Hall did not in fact put Pope's invention into practical form in April, 1873, and the court below, therefore, was mistaken in its deductions of fact from the evidence, as well as in the legal deductions which he drew from what he erroneously considered to be facts proved by the evidence.

IV.

THE OTHER CLAIMS OF THE DEFENDANT AS TO PRIOR INVENTION.

1. The defendant has set up in his answer that Pope's invention or material parts thereof had been known to and used by Thomas S. Hall, and also by Elery P. Warner, and John B. Odell.

We have considered what was done by Hall, and in relation to Odell and Warner, no evidence was introduced except two patents to him and Warner, which we shall consider hereafter.

2. The defendant has set up in his answer that Pope's discovery "or substantial and material parts thereof" had been described in certain American and English patents, which he specifically refers to (Record p. 9).

This allegation is not sustained by the proofs. Pope's discovery is a combination of old and well-known devices, and even if some of the elements thereof had been previously described in the patents referred to, that is no defense, as it is well settled that in a combination patent, it is no defense that any or all of the elements are old, if the combination is new. It has been held by this court in Bates *vs.* Coe, 98 U. S., p. 31, that such an answer is insufficient, but as there is nothing in any of the patents named which covers this invention, we do not need to insist on this point.

We will consider briefly the patents in evidence. There are nine referred to in the answer, but only four of them were put in evidence by the defendant.

1st. American patent to Warner and Odell, No. 130,612, dated August 20, 1872. Defendant's Exhibit, No. 47, Exhibit Books, 231.

No testimony was offered by the defendants to show that the invention of Pope was found in this patent, and of course the plaintiff offered none. In the absence of expert proof as to the contents of the patent, the court will not trouble itself to make the investigation.

2d. American patent to T. S. Hall, No. 118,606, August 29, 1871, Exhibit Book, p. 149.

There is nothing in this patent showing Pope's invention, it is for an entirely different one. Hall's own evidence shows that it was more than a year after this, viz.: in December, 1872, before this combination occurred to him.

3d. English patent, No. 305, Feb. 7, 1854, to Urbain Bianchi, Exhibit Book, p. 175.

In regard to the invention shown in this patent, Professor Morton, the defendant's expert, in his direct examination, p. 243, Record, Int. 12, only says that he finds in this patent

"important features" of Pope's invention, and on cross-examination, p. 264, Cross-Int. 56, he is obliged to confess that both the result obtained by the arrangement described in that patent, and the arrangement itself by which that result is obtained are "materially different" from those of Pope.

4th. English patent, No. 2,807, Nov. 1861, to William Clark, Exhibit Book, p. 201.

Prof. Morton in answer to Cross-Int. 58, page 264, says that he does not find in this patent the combination claimed in Pope's patent.

As to the patents referred to as showing the state of the art, it is well settled that they cannot be used to defeat a patent, but if they could, there is nothing in them which shows Pope's invention. The answer also refers to various patents issued to Hall (Record p. 10, folio 22), but it does not refer to these as containing Pope's invention, and, therefore, we shall not consider them.

V.

OTHER CLAIMS SET UP IN THE ANSWER.

These are three in number, viz.: That the specification is not sufficient, that no invention is shown in the combination patented, and that the invention or material parts of it had been in public use by Hall for more than two years before Pope's application.

First.

As to the specification not being sufficient.

Since the decision in Loom Co. *vs.* Higgins, 105 U. S., p. 580, it hardly seems necessary to go over the evidence at length on this point.

It was held in that case that the description in the specification is to be considered as if read by a person thoroughly skilled in the art relating to which the invention was made. In the case of a combination of old and well-known devices it is not necessary to describe them all at length, or state the precise method in which each one is to be used in detail, if it would be familiar to an expert in such matters.

Pope's invention consisted as we have stated of a combination of one battery, two or more circuit-closers and magnets, and a positive and a negative conductor arranged as described.

Four witnesses on the part of the defendant testify on this point, Morton, Alvah Hall, Shaw, and Thomas S. Hall.

The grounds of their objections are substantially, that the precise kinds of magnets, signals, and track circuit-closers, are not specifically described, nor any special method adopted of equalizing the resistances.

But all these were matters well known to and understood by every one skilled in the art of applying electricity to the working of railroad signals, and the evidence in the case relating to the state of the art in 1872, shows this clearly. Pope had put up and used in 1871 a track circuit-closer and signal, such as were needed for the use of his combination; the magnets were well known, and Morton himself says, in his answer to Int. 22, p. 250 of Record, that the difficulty arising from the want of equalization of resistances "could be overcome by the *familiar process* of equalizing resistances by the use of resistance coils and the like; these resistance coils had been in constant use for the purpose of equalizing resistances in circuits for a long time prior to the date indicated, and in a multitude of instances."

Both Mr. Pope and Mr. Farmer substantially state the same thing, and the latter says in his answer to Int. 6, p. 114, Record:

"I think that the knowledge which should be possessed by a competent person skilled in the art, taken in connection with the instructions contained in Mr. Pope's patent should enable such person to decide beforehand upon the amount and arrangement of the necessary battery, the size and construction of the electro-magnets, and the *dimensions of the conductors to be used* so as effectually to prevent the burning and destruction of the circuit-closers referred to, without making the tedious and long-protracted experiments referred to. *I think that necessary knowledge could be obtained from books printed before the obtaining of this patent.*"

SECOND.

The defendant insists that there is no invention shown in Pope's patent.

The best answer to this claim is found in the acts of Thomas S. Hall, himself.

On pages 221 and after, of Record, he gives a detailed account of what he claims to be his own invention of Pope's plan.

He says that in 1872 he became convinced that his signal system needed improvement, that he gave the subject much thought and study, and during that year conceived a plan "that convinced me perfectly that I had made the improvement desired."

He immediately wrote to his son (in the latter part of December, 1872) to come from Salem to Meriden, explained to him what he had thought of, and sent him to put up wires on the wall of his work-shop to try the experiment. This his son did, and told his father that it "would not work, and he knew it would not," but his father helping him, at last made it work to his satisfaction. He then sent such an urgent dispatch to George H. Snow, his principal workman, who was in

Salem putting up the old system of Hall's signals, to come at once to Meriden, that he dropped everything and came on, saying that he supposed Hall must be sick. Hall then told Snow he wished to stop all work at Salem, for he had a new plan which he explained to him, and Snow said, "it can't be done." Hall then took him into the work-room and explained the arrangement to him, and he exclaimed that it was done.

Hall and Snow then at once went to work to get ready to put up signals on this *new* plan, giving up his former plans, and it does not appear that he has ever used his old plans since.

Moreover, Hall, in the same year, actually applied to the patent office for a patent for this invention, as set out in the first claim on page 71 of the Book of Exhibits, and the office refused to grant him a patent on the ground that the invention had been patented by Pope by the patent in suit.

After this it does not seem necessary to consider and argue at length the question whether there was any "invention" in this improvement.

THIRD.

That Pope's invention was publicly used by Hall for more than two years before Pope's application.

What is said under the last point is equally applicable to and decisive of this.

VI.

AS TO INFRINGEMENT.

An examination of the drawing of Pope's patent, Exhibit A, facing page 1, and of Exhibit C, facing page 6, of Exhibit Book, which latter shows the apparatus erected by the defend-

ants and claimed to be an infringement, makes it apparent that they are alike in every particular but this, viz.: The positive and negative conductors shown in Pope's drawing, are of continuous wire, so that the electric current travels along wires through the whole of both circuits, while the defendants use similar positive and negative conductors of wire but not continuously, part of the circuit is formed by one of the wires or conductors, in this case the negative one, being connected with the earth, so that the earth enters into and forms part of the circuit. The electric fluid, instead of passing along conductors made of wire all the way, passes along one conductor made wholly of wire, and another made partly of wire and partly of the earth, which acts as a conductor in the same manner as the wire does.

The combination shown in both drawings has the same elements, and works in the same way in actuating the signals in each, but it is claimed by the defendants that this substitution of the earth for a part of the wire, makes a new and different invention from that of Pope.

FIRST.

It will be noticed that no particular kind of conductor is claimed in Pope's patent. It says, "two wires or *other conductors*, one attached to the positive and negative poles of the battery B."

His invention is for a combination, one element in which, as in all electrical combinations requiring an electrical circuit to be formed, is two conductors, one positive and one negative, over which the fluid is to pass. The connection of these wires forms a circuit, and their separation breaks the circuit.

Now any conductor which will carry the electric fluid may be used in this combination. There are many such which were well known in 1872.

Even if Hall had discovered and used some entirely new kind of conductor never known or used before, it is doubtful if such use would not be an infringement when used in this combination, but the use of the earth as a conductor has been known since 1837, and has always been used in all systems of telegraphy ever since that time.

Almost exactly a similar case to this is Electric Telegraph Company *vs.* Brett, 10 Com. Bench, 838 (4 Eng. L. & Equity Rep., 347), decided in 1851. In that case the plaintiff's patent claimed "improvements in giving signals by means of electric currents transmitted through *metallic* circuits." After the date of their patent, it was discovered that the earth might be used as a conductor, and the defendants claimed that the patent called for "metallic circuits," and they used a circuit only part of which was metallic. But the court held that the patentees did not claim any particular kind of conductors as their invention, and that the use of the earth instead of a portion of the wire was not even an equivalent for a part of the combination claimed, but merely one way of doing a well known incidental thing, which did not prevent their use of the patented invention from being an infringement. This case is exactly in point, both to show that the use of the earth as part of a circuit is old, and also that its substitution for wire does not make a different invention.

But the defendants claim that they are using a different invention from Pope's, because they say that by using the earth as part of the circuit, *the resistances of the different circuits are equalized better* than by the use of all wire as shown in Pope's drawing.

That is to say, that *although they use the whole combination that Pope patented*, yet because they equalize the resistances in a different manner from that pointed out in his patent, they do not *use his invention.*

From Exhibit C it appears that the infringing combination contains, as in Pope's claims, a battery B, in combination with the positive and negative conductors C and Z, two or more electro-magnets M and M, and two or more circuit-closers *a*, *a*, placed at intervals along the line of a railroad to actuate signals, in the same manner as shown in the drawing of Pope's patent. Pope, p. 14, and Farmer, pps. 17 and 18, say that it is the same thing as Pope's, and the defendant's witnesses do not deny that the combination is the same in both, but place their principal distinction on the method of equalization of resistances in the defendant's plan.

Now this equalization of resistances is no part of Pope's invention. It is not mentioned or referred to in any of the claims. It is only a matter of detail in the adjustment of the several circuits, and is so stated in his specification (page 4 of Exhibit Book).

"The respective resistances of the several circuits should be *so adjusted* that they will be as nearly as possible equal to each other, as a much more perfect action of the apparatus will be secured thereby."

Resistance, as has already been stated, is obstruction of the electric fluid; it is something like the obstruction caused by friction to the flow of water through pipes. The fluid flows more readily along a large wire than along a small one, and if a piece of small wire is placed between two large wires and a very strong current of electricity is sent along the whole, the fluid finds so much difficulty in driving so large a current through the small wire that it will heat it, or even melt it.

Where one battery was used for each circuit it was not necessary to pay attention to this subject of resistances, but where one battery is used for a large number of circuits differing in length, the amount of electricity required to work the longest circuit may be so great as to destroy the wire on the shortest circuit, unless it is properly arranged.

There have long been many ways in which this could be done. The most obvious is to have the wires on the short circuits larger than those on the long circuits. Mr. Farmer, on pages 18 and 19 of Record, says that there are many practical ways of equalizing these resistances, and that it "presents no difficulty at all to a competent electrician." Prof. Morton, on p. 268, says the circuits could be equalized "by the use of resistance coils or their equivalents, which were well-known devices for producing just such results."

Mr. Snow, on page 189 of Record, after stating on page 188 that the using the earth as part of the circuit was adopted for the sole purpose of equalizing the resistance, says: "I thought of some other methods, but did not try them."

Mr. Farmer, on pages 76 to 83 of Record, considers this question at length, and shows that the method of equalizing the resistance was only a matter of practical detail which could and should have been considered beforehand, and could easily have been arranged in various ways by a simple computation.

Much stress is laid by the defendant's witnesses upon the fact that when Hall endeavored, in 1874, to use his apparatus on a railroad, his workman, Snow, found that it would not work on account of the difference in length of the circuits, but on page 174 he says the reason was that the magnets used, being wound with coarse wire and adapted for short circuits, required so much battery power to work them on the long ones that the points of the circuit-closers were destroyed.

It was evidently because he did not consider beforehand the relative proportions of the apparatus to be used. It is exactly as if he had used a battery of too small or too great power. If he had been "skilled in the art" he would have had no trouble, but he was merely a good practical workman

who had never studied the subject at all. Before 1870 he was only a machinist, knowing nothing special about electricity.

One other difference is suggested between the plan of Pope and that used by the defendants, viz.: that the former causes the circuit to be closed by insulating sections of the track, and the latter by using a particular form of track circuit-closers. But this also is a mere matter of detail; the *method* of closing the circuits is no part of Pope's invention, and he says in his specification, Exhibit Book, p. 4:

"I do not desire to confine myself to the use of any particular form of visible or audible signal, *nor to the particular devices herein described for closing the electric circuits* at points from which the signal is to be operated. Instead of the circuit being closed automatically by the train itself, it may be closed by a signal man by means of a key or switch, *or otherwise*."

As it appears, therefore, that the defendants use exactly the same combinations as those described in the claims of Pope's patent, and that the only differences are mere matters of detail, not parts of the invention, it is clear that the defendants infringe.

The judgment below should be reversed and a decree awarded for the plaintiffs.

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Office Supreme Court U. S.
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JAMES H. McKENNEY,
CLERK.

Supreme Court of the United States.

OCTOBER TERM, 1884.

THE ELECTRIC RAILROAD SIGNAL CO.

APPELLANTS,

vs.

THE HALL RAILWAY SIGNAL CO.

APPELLEE.

No. 141.—Equity Appeal.

BRIEF FOR APPELLEE.

SIMEON E. BALDWIN,
Counsel for Appellee.

NEW HAVEN:
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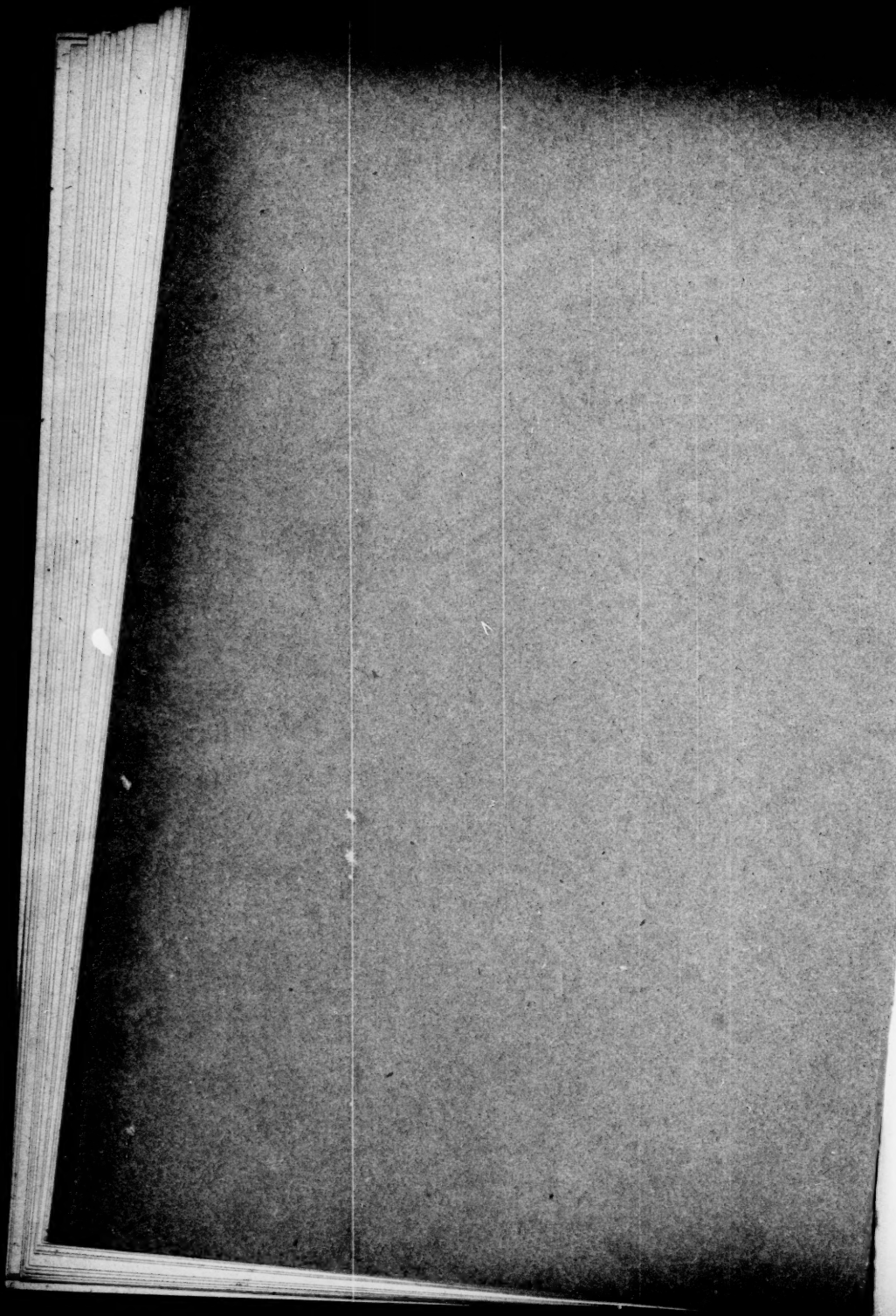
1884.



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APPELLEE.

In Equity.—No. 141.

BRIEF FOR APPELLEE.

STATEMENT.

This is a bill brought in the Circuit Court for the District of Connecticut for an account and injunction against an infringement, grounded on a patent for an improvement in circuits for Electric Railroad Signals, granted to Frank L. Pope, under date of July 1, 1873 (No. 140,536). The case was fully heard on bill, answer, and proofs, and a decree rendered in 1881, dismissing the bill with costs, mainly on the ground that the defendant's assignor and not the plaintiffs', was the original inventor of the improvement in question. The plaintiffs were Frank L. Pope, Stephen C. Hendrickson, James N. Ashley, and James D. Lincoln, co-partners under

the firm name of "The Electric Railroad Signal Company," claiming under an assignment from Pope, dated July 1, 1875. Mr. Ashley died prior to this appeal.

The patent described in the assignment (Complainants' Exhibit B, pp. 5, 6). is one "for certain improvements in circuits for electric railroad signals, which Letters Patent bear date the first day of July, one thousand eight hundred and seventy-three, and numbered 129,425."

Mr. Pope, at this time, owned two patents: one dated July 16, 1872, No. 129,425, for an "Improvement in Electric Signáling Apparatus for Railroads" (Complainants' Exhibits, pp. 42, 43), and another dated July 1, 1873, No. 140,536, for "Improvements in Electric Signaling Apparatus for Railroads," as it is styled in the specification, or "Improvement in Circuits for Electric Railroad Signals," as it is styled in its Patent Office title (Complainants' Exhibits, p. 2). Both patents relate to electric circuits for actuating railroad signals.

It is admitted that the defendant has used extensively, and set up on many railroads, certain of the improvements in electric signaling apparatus, which the plaintiffs claim to be covered by the patent in suit.

The defense is that this patent, if owned by the plaintiffs, is invalid, for want of novelty, utility, and certainty; that Thomas S. Hall, the defendant's assignor, and not Frank L. Pope, was the first and original inventor of the improvements, as to which the infringement is claimed; and that, if the Pope patent be valid, the defendant has not used the combination thereby protected. The Circuit Court dismissed the bill with costs, resting its opinion on the ground, that waiving all other questions, Mr. Hall was the prior inventor of the system of signaling used by the defendant, and claimed to infringe the complainants' patent.

This patent, No. 140,536, is a patent for a combination of old devices for use in "block-signaling" on railways. The end to be attained is to preserve a certain distance between all trains, following each other on the same track, and to do this at the least possible expense. Various devices had been tried from time to time for this purpose, all on this general plan:—to set up a series of signal-discs or signal-bells at the proper distances along the track, and first to display or sound each, and then conceal or silence it, by the agency of an electric-circuit formed or broken simultaneously with the passage of the train. Each signal guarded a certain section or "block" of the track. As the moving train entered any section, the signal on the section, or block, behind it was made to assume a position denoting *Danger*, and it remained there until the former section was cleared, upon which it returned to a position denoting *Safety;* and the same operation was repeated as the train rolled on over each successive block. The electric-circuits, which produced these effects, were worked by two independent batteries for each signal or pair of signals. On a long line, the number of batteries employed was therefore considerable; and as only two of them were needed at any one time, since only one signal or pair of signals was to be operated at any one time, it was evidently a great desideratum to get rid of as many of them as possible.

Thomas S. Hall, the assignor of the defendant, invented a plan in 1872, whereby one battery does all the work for a long series of signals, by the aid of his "double-circuit instrument" patented Dec. 7, 1869, No. 97,505 (Defendant's Exhibits, No. 22, p. 117). This invention had for its object to keep a signal, once displayed by a passing train, in its position of display long enough to allow the train to get upon the next succeeding block, and send back from thence a releasing current.

It consisted in placing two electro-magnets near each other, in such a position that throwing an electric current through one of them and attracting its armature, would draw away the armature from the other, so that closing one circuit always broke the other circuit. Thus by use of a spring lever, and a locking detent or latch, the armature when attracted to its magnet, was kept in that position after the attracting current had spent its force; and until a releasing current through the other magnet, by attracting its armature, operated mechanically on the other armature, and allowed it to fall back to its normal distance. By connecting the main armature, therefore, by a pivoted lever or otherwise to the signal, this signal could be kept displayed, until a current was sent back on the other circuit to release the spring, drive the armature off from the magnet, and thus break the electric circuit which embraced the signal.

Mr. Hall, by the aid of this double circuit instrument, arranged a combination of main and subsidiary electric circuits to actuate and release a series of signals, all operated by one fixed battery, and brought into action by the impact of the moving train itself, as it goes along. It proved a measure of great economy, and is particularly described in one of the patents under which the defendants claim, No. 165,570, of July 13, 1875.

The complainants claim that this combination infringes the patent granted Mr. Pope on July 1, 1873, No. 140,536.

They admit that Thomas S. Hall was the father of the American system of electric railroad signaling apparatus, and that it was through his inventions and explanations of them that Mr. Pope's attention was first called to the subject.

Mr. Pope testifies as to this, as follows:

"My attention was first called in any way to the subject of electric signals for railways in the year 1867, to the best of my recollection. I was at that time employed as superintendent of a telegraph for reporting the quotations of prices of gold, which was worked in connection with the Gold Exchange, in New York City. I was also at that time editor of *The Telegrapher*, a weekly journal devoted to telegraphic and electrical news. At the time of which I speak, I received an invitation to attend a lecture on this subject, to be given by Prof. R. O. Doremus, at what is now the College of the City of New York. I attended this lecture, and among the electrical apparatus which was exhibited and explained by the lecturer, was an electro-magnetic signal apparatus, which was stated to be the invention of Mr. Thomas S. Hall. This apparatus was explained in detail by the lecturer, and its operation exhibited in connection with railway switches and draw-bridges.

"This idea was then entirely new to me, and as an electrician I was much interested in it. At the close of the lecture, I either introduced myself to or was introduced to Mr. Hall (who was present at the lecture), and had some little conversation with him in relation to his invention, with a view of preparing a notice of it for publication in my paper, which notice I afterwards prepared and published."

Complainants' Evidence, Record, p. 39.

A similar recognition of Mr. Hall's early inventions is contained in Mr. Pope's article of April 3, 1872, in the *American Artisan*, Exhibit 1.

Defendant's Evidence, Record, p. 275–277.

Mr. Hendrickson, another of the plaintiffs, also became first acquainted with electric railroad signaling, as an employee of Thomas S. Hall, or of the Hall Electric Railway Draw-bridge and Switch Signal Co., of which Mr. Hall was the manager, in 1868, 1869 and 1870.

Complainants' Testimony, Record, p. 29.
Defendant's Evidence, Record, p. 212, pp. 293, 296.

It is further admitted that, subsequent to his knowledge of Mr. Hall's invention, Mr. Pope commenced experimenting in the same field, and that both he and Mr. Hall afterwards took out

separate patents, apparently designed to accomplish the same general purpose above explained, namely, to indicate a mode of constructing an electric apparatus, by which a series of signals can be automatically displayed and reversed, along the line of a railroad, in a definite and pre-arranged succession, by the use of a single battery. Mr. Pope's patent was issued July 1, 1873, and Mr. Hall's (to Hall and Snow) not until July 13, 1875, but Mr. Hall claims to have been the first to discover the improvement in question, and to put it in a patentable form.

We will discuss first the question of infringement; second, the validity of the Pope patent; third, the complainant's title; and, fourth, that of priority of invention; adopting this order because, if we are right in our claims as to any one of the points first mentioned, it becomes unnecessary to examine the mass of evidence as to the last.

POINTS.

I.

There has been no infringement.

The defendant, if we assume the patent No. 140,536, to be valid, and to be owned by the plaintiffs, has not infringed the combination patented.

The systems of each party are identical in their object, mainly to actuate a series of visible or audible signals, set at intervals along the line of a railroad, by means of a single battery, through one main circuit and several subsidiary circuits. They differ in their method of accomplishing this object.

1.

The Rails a necessary part of Pope's Circuit.

And, first, the complainant's system was an entire metallic circuit, and makes insulated sections of the rails a part of it: the defendant's system never uses the rails as part of the circuit,

and always includes the earth. The complainant's system closes the circuit by the contact of the wheels and axle of a passing train, or of a connecting rod moved by a switchman, with the insulated rails on either side of the track. The defendant's system closes the circuit by causing two springs outside of the track and unconnected with it, to be brought together by the action of a lever depressed by a moving train, whereby a circuit is established through wires running over or under the track.

Mr. Pope in his evidence in chief, thus describes the operation of the defendant's application of its system at Chelsea, Mass., which was the infringement relied on.

"A circuit closer was placed upon the track at a point near the signal, which consisted of a lever so placed as to be depressed by the wheels of a passing train, which movement caused the circuit to be closed by pressing two springs together." Record, p. 14.

His testimony shows, also, that from the very first beginnings of his system, he has adhered to the all-rail circuit.

In speaking of his experimental application on the Boston, Lowell and Nashua railroad in 1871, he says:

"At a point opposite the station in East Cambridge, a mile or two from the Boston station, a section of the right hand rail of the outward-bound track, forty-two feet in length, was insulated from the adjacent line of rails in each direction." (Record, p. 44.) . . . "I will here remark that this insulated section was purposely made long enough, so that the circuit would remain closed while the entire train was passing over it, thus giving plenty of time to swing into position, even though that operation might require several seconds." (Record, p. 45.) "Another experiment which I made within a few days after the signal was first put in operation was for the purpose of testing the degree of insulation of the track circuit-closer at East Cambridge." (Record, p. 46.) . . . "The apparatus and system which I have

described and which was thus operated from the 9th of November, 1871, to the latter part of February, 1872, contained two of the *essential elements of the combination afterwards patented* by me in patent 140,536, (Complainants' Exhibit A,) viz: A circuit closer which, when operated by a railroad train moving at any practicable rate of speed, will remain closed long enough for a signal-disc to be moved into position by the action of an electro-magnet, even if the operation requires several seconds, as is the case when a small battery-power is used; also a signal disc, provided with a lock," etc. Record, p. 46.

Describing the application which he made near Pittsburg, in 1872, he says:

"When a westward-bound train, leaving the stock yards at East Liberty passed over the *insulated section of track forming the circuit-closer*, near Roup's station, it closed the circuit of a battery, which actuated a relay in the signal-box, which contained the signal, and was placed upon a post at the right-hand side of the track. This circuit remained closed, while the *entire train was passing over the circuit-closer.*" Record, p. 49.

In 1873, he makes another application on the Lehigh Valley railroad, of which he says:

"The continuous insulated section of track was about five thousand feet in length. The signal was placed at the entrance of the insulated section, and was so arranged as to indicate 'danger,' when in its normal position; which indication was changed to 'safety' by the action of the battery, as the engine approached the signal. As soon as the engine had passed the signal, the connection made across the insulated rails, from one side of the track to the other, by the wheels and axles of the train, cut the battery current off from the signal-magnet, allowing it to fall back to its normal position indicating 'danger;' and the battery remained thus cut off from the signal as long as any portion of the train remained upon any part of the five thousand feet of insulated track." (Record, p. 57). "I experimented some weeks with this system at Bear Creek, and at length got it so that the insulated section of five thousand feet in length performed its *functions as a continuous circuit-closer* perfectly and under all conditions of weather, so much so that the officers of the Lehigh Valley Company, after a long and thorough test, stated that they were fully satisfied with the reliability of the entire system then shown." (Record, p. 58.)

If now we look at the terms of the patent No. 140,536, which he claims as the result of these experiments, we find that the very soul of his combination is this use of an insulated section of the track to constitute the circuit-closer, when operated upon by a moving train or other device to connect the opposite rails. He says in his specification referring to the drawings annexed:

"In the accompanying drawing, A A represent a portion of the track of a railroad. At intervals of, say, a mile, more or less, sections of the said track, a a^1 a^2, are electrically insulated from the remainder in a manner well understood, and therefore requiring no detailed description. B is a galvanic battery, of any suitable construction, and placed in any convenient location near the line of the railroad. Two wires or other conductors, C and Z, are attached to the positive and negative poles, respectively, of the battery B, and extended to any required distance in a direction parallel or nearly so to the line of the railroad. The conductors C and Z may be placed on poles and should be suitably insulated from each other and from the earth. The conductors C and Z are virtually prolongations of the positive and negative poles of the battery B. Each of the insulated sections of track a a^1 a^2, etc., is placed at some point at or near which it is desired to erect a signal, and any required number of these may be employed to meet the requirements of any particular case. M, M^1, and M^2 are the electro-magnets, which actuate or display the respective signals. The said signals may be of any suitable construction, and should be provided with some suitable means of retaining them in position or action after the circuit through the magnets M, M^1 or M^2 has been interrupted. m, m^1, and m^2 are magnets so arranged as to release, reverse, or stop the action of said signals, which have previously been brought into action by the magnets M, M^1, and M^2.

The operation of the apparatus is as follows: Suppose a train moving along the track A A from left to right in a direction indicated by the arrow. Upon reaching the point a, the wheels and axles of the train will form an electrical connection between the opposite insulated rails, and a circuit will be formed between the conductor C and the conductor Z, traversing wires 1 and 2, magnet M, and wire 3, and the signal attached to M will consequently be displayed. Upon the arrival of the train at a^1 the same operation will be repeated, and another connection formed between C and Z, traversing

the wires 4 and 5, magnet M^1, and wire 6, while at the same time a portion of the current will traverse the branch-wire 7, magnet *m*, and wire 8. Thus the signal attached to M^1 will be actuated, and simultaneously the action of the magnet *m* will release or reverse the action of the first mentioned signal. Upon reaching the point a^2 the closing of the circuit by the train will, in like manner, cause the signal attached to M^2 to be displayed, and the signal last displayed by M^1 to be withdrawn. In this manner any required number of such signals may be operated by means of a single battery."

Complainant's Exhibits, pp. 2–4.

The apparatus erected by the defendant at Chelsea, which is relied on to show an infringement, (Complainant's evidence, Record, pp. 13, 14,) does not include the rails in the circuit. But Mr. Pope, in the patent sued on, forms his circuit only by connecting the opposite rails of insulated sections of the track. He gives two modes of making the connection: automatically, by the wheels of a passing train, or by a signalman with a hand-key, or switch (Complainant's Exhibit A, p. 4); but the insulated rails are in either case a part of the circuit.

In our Chelsea application (Exhibit C), an independent track circuit-closer was used, and the rails were no part of the circuit. See Defendant's Evidence, Record, p. 250.

Complainant's Exhibits, Exhibit C, p. 6.

This difference was the first one mentioned by President Morton in his answer to Int. 11. Record, p. 242.

"Int. 11. Please compare complainant's patent with a copy of complainant's Exhibit C, and state whether or not you find the two systems shown and described therein to be alike, and if not alike, what difference do you find between them?

A. I find the system shown in the drawing, Exhibit C, to differ from that described in complainant's patent in several important particulars; in the first place, the drawing Exhibit C, does not show a method of closing the battery circuits and thereby actuating the signals by means of insulated sections of railroad track, as described in complainant's patent, but as

closed by some independent circuit-closing apparatus, not mentioned in the patent."

In other words, the plaintiffs' system always includes the rails in the circuit; the defendant's system always excludes them. The plaintiffs' patent depicts them (a, a^1, a^2), as the most prominent parts of the model and drawing, and the specification begins and ends with them. Without them, there is nothing possible, and no hint that they can be replaced by anything else was ever suggested until Mr. Pope, on his evidence in rebuttal, undertook to meet President Morton's testimony in regard to this fatal difference in the two combinations, as follows:

"Furthermore, the specification states that the invention is not confined to the use of the particular devices therein described for closing the electric circuit at points from which a signal is to be operated. In his answer to Cross-Int. 45, Prof. Morton says that other devices for closing a circuit by the action of a moving train, which did not depend on the insulation of the track or any portion thereof, were known, patented, and described in printed publications, prior to the date of complainants' patent. The specification describes a known construction of circuit-closer, which had been thoroughly tested, and was considered by the patentee the best, though by no means the only apparatus for the purpose, which was at that time available." Record, p. 72.

The difficulty with this attempt to evade the point now under consideration, is, not only that President Morton's answer to Cross-Int. 45, thus referred to (Record, p. 259), shows that no other devices for closing a circuit by a moving train had proved successful except those covered by the defendant's patents, but that the specification and claims of the complainants' patent, as well as Mr. Pope's own previous testimony (Record, p. 46), make the use of insulated sections of the rails as the circuit closer an "essential element of the combination." The drawing shows a, a^1, a^2, as insulated sections of the track,

on connecting the opposite rails of which by a train or a switch or key the circuit is closed in the manner stated in the specification. The first claim which is for actuating signals, names as one element of the combination "two or more circuit-closers, a, a^1, a^2, placed at intervals along the line of a railroad." The second claim, which is for reversing signals after they have been actuated, names as one element of the combination, "two or more circuit-closers a^1 a^2 placed at intervals along the line of a railroad." The third claim, which is for first actuating and then reversing signals, names as one element "circuit-closer a," and as another, "circuit-closer a^1."

Complainants' Exhibit A. pp. 4, 5.

Mr. Pope's patent cannot be infringed save by the use of every one of the necessary elements of his combination, or their known equivalents. The circuit formed without the rails cannot be deemed to perform "the same function in substantially the same way" as the circuit formed by the rails.

"The same result may be reached by different processes, each of them patentable, and one process is not infringed by the use of any number of its stages, less than all of them."

Goodyear Dental Vulcanite Co. vs. Davis,
102 U. S., 222, 224, 230.

Mr. Pope has not patented the idea of operating a series of signals by the use of a single battery.

"The idea he could not patent, but his contrivance to make it practically useful he could. By his patent he appropriated to himself only so much of the field of invention, which his idea embraced, as was covered by the machine, described in his specification and claimed in his application."

Wicke vs. Ostrum, 103 U. S., 461, 467.

No one can infringe his rights who does not use all the parts of his combination, or what are known equivalents for all of them.

Prouty vs. Ruggles, 16 Pet., 336, 341.
McMurray vs. Mallory, 111 U. S., 97, 103.

2.

POPE'S CIRCUIT ALL METAL; OURS, PART EARTH.

It is also an essential element of the combination in the complainants' patent, that the circuit, when closed, be an entire metallic circuit, whereas it is the characteristic feature of the defendant's system that the circuit be not an entire metallic circuit. We introduce the earth as part of the circuit, and our evidence demonstrates that its introduction is necessary to the successful working of our system, and of any system designed to accomplish the same result.

As to this use, in the complainants' patent of an entire metallic circuit, Mr. Pope says in his specification:

"*Two wires or other conductors, C and Z,* are attached to the positive and negative poles, respectively, of the battery B, and extended to any required distance, in a direction parallel or nearly so to the line of the railroad. The conductors C and Z may be placed on poles, and should be *suitably insulated from each other, and from the earth.*"

Complainants' Exhibit A, pp. 2, 3.

In each of his three claims, also, these two conductors, C and Z, as well as the rail circuit-closers, form part of the combination.

It is not open to him now to say that conductor Z may be dispensed with, and his patent still be infringed.

Vance vs. Campbell, 1 Black, 427, 429.

"The Courts of this country cannot always indulge the same latitude which is exercised by English judges, in determining what parts of a machine are or are not material. Our law requires the patentee to specify particularly what he claims to be new; and if he claims a combination of certain elements or parts, we cannot declare that any one of these elements is immaterial. The patentee makes them all material by the restricted form of his claim."

Water Meter Co. vs. Desper, 101 U. S., 332, 337.
Gage vs. Herring, 107 U. S., 640, 648.

It is suggested by the complainants' counsel that introducing the earth into the circuit is merely one of many modes of equalizing the resistances incident to circuits of unequal length, which were contemplated by the terms of Pope's specification, in which he says:

"The respective resistances of the several circuits should be so adjusted that they will be as nearly as possible equal to each other, as a much more perfect action of the apparatus will be secured thereby."

Exhibit A, Complainants' Exhibits, p. 4.

But his claim not only does not indicate any mode of adjustment, but by incorporating conductors *C* and *Z* and the rail circuit-closers (a, a^1, a^2), expressly makes each circuit all metallic. If the claims are narrower than the preceding specification, the claims control.

"Though the claim may be illustrated, it cannot be enlarged by the language used in other parts of the specification."

Railroad Co. vs. Mellon, 104 U. S., 112, 118.

It may be suggested by counsel here, as it was in the Court below, that the claims of Mr. Pope's patent are enlarged, by his addition to each, of the words "substantially as and for the purpose specified" or "substantially as specified." But this general and common phrase can have no other effect than to point out the substantial purpose to be accomplished by the whole invention. It cannot extend the claim to anything that is not claimed.

In a recent case in this Court, between rival patentees of an automatic device whereby an oven shelf may be raised by closing the door, the complainant, and prior patentee, had phrased his claim thus:

"What I claim and desire to secure by letters patent is—In combination with a stove oven, a hinged shelf, fitted to fall outward and down automatically, when the oven door is

opened, and to be raised up by closing the oven door, adapted to operate upon it for that purpose, *substantially in the manner and for the purposes herein set forth.*"

The description of the device previously given stated that it was a cam attached to the door, which was pushed under the shelf, as the door was shut; the shelf falling again, by its own weight, as the door was opened. The defendants had patented a device for a similar purpose consisting of a cam attached to the door, which, as the door was shut or opened, operated upon a projection attached to the upper side of the shelf so as to raise or lower it. The Court held that there was no infringement, because the prior patentee "if entitled to anything, is only entitled to the precise device which he has described and claimed in his patent."

Bridge vs. Excelsior Co., 105 U. S., 618, 619.

The complainants claim nothing new but the combination.

"In such a claim, if the patentee specifies any element as entering into the combination, either directly by the language of the claim, or by such a reference to the descriptive part of the specification as carries such element into the claim, he makes such element material to the combination, and the Court cannot declare it to be immaterial. It is his province to make his own claim, and his privilege to restrict it. If it be a claim to a combination, and be restricted to specified elements, all must be regarded as material, leaving open only the question whether an omitted part is supplied by an equivalent device or instrumentality.

Fay vs. Cordesman, 109 U. S., 408, 420.

Unless then the use of the earth, in lieu of one of these conductors C and Z, is the mere substitution of a mechanical equivalent, it is clear that we are not using the combination secured by Pope's patent.

Eames vs. Godfrey, 1 Wall, 78.

But is it, in the nature of things, possible to say that the use of the earth as a return conductor is the equivalent of the

use of a wire or other conductor, extended to any required distance, in a direction parallel or nearly so to the line of the railroad, which conductor may be placed on poles, and *should be suitably insulated from the earth*, and is virtually a prolongation of the negative pole of the battery?

And even could this direction, requiring insulation from the earth, be disregarded, insuperable difficulties still remain, in view of the settled limitations of the law of equivalents, as applied to such a combination. The patentee of a combination of old elements

"may doubtless invoke the doctrine of equivalents, as against an infringer of the patent: but the term 'equivalent,' as applied to such an invention, is special in its signification, and somewhat different from what is meant when the term is applied to an invention consisting of a new device or an entirely new machine. . . Patentees of an invention consisting merely of a combination of old ingredients are entitled to equivalents; by which is meant that the patent, in respect to each of the respective ingredients comprising the invention covers every other ingredient which in the same arrangement of the parts will perform the same function, if it was well known as a proper substitute for the one described in the specification, at the date of the patent. Hence, it follows that party who merely substitutes another old ingredient for one of the ingredients of the patented combination, is an infringer, if the substitute perform the same function as the ingredient for which it is so substituted, *and it appears that it was well known, at the date of the patent, that it was adaptable to that use.*"

Imhaeuser vs. Buerk, 101 U. S., 647, 656.

The earth is, properly speaking, no conductor at all. It is the great ocean of electrical force into which all electrical currents naturally gravitate, and in which they mingle and become lost. You cannot telegraph or actuate an electric circuit through a part of the earth. Its agency in the circuit is simply to put the wire in a traversable state.

How can, then, grounding a wire at the foot of the battery,

in order to equalize the circuits in an apparatus for operating electric railroad signals automatically and successively by the use of one battery, be deemed to have been, at the date of the Pope patent, "well known as a proper substitute" for continuing that wire, insulated on poles or otherwise, so arranged as to form a series of unequal circuits, for a distance of miles along the track of the railroad?

Seymour vs. Osborne, 11 Wall, 516, 556.
Gould vs. Rees, 15 Wall, 187, 192–194.

We did not use the earth simply to take the place of a wire, in order to conduct an electric force from one point to another. We used it to fulfill a function which that wire never could fulfill, and was never designed to fulfill, namely, to make every electric circuit in the whole apparatus exactly equal in length, and therefore in resistance.

Gutta percha may have long been used as a suitable covering with which to encase wires, but when it was first used for this purpose with the design of insulating them so as to make them good electrical conductors, the device was patentable.

Colgate vs. Western Union Tel. Co., 15 Blatch., 365, 367.

Vulcanite had been moulded into many forms, before anybody thought of using it in the manufacture of artificial teeth; but inasmuch as, when thus used, the product, as compared with that resulting from the use of a metallic plate, is one "that has new capabilities, and that performs new functions," the substitution was held to be a work of invention.

Smith vs. Goodyear Dental Vulcanite Co.,
93 U. S., 486, 496, 497.

The novelty of our use of the earth as part of our circuit, in order to equalize the circuits, is *prima facie* established by our having obtained a patent for it, in 1875, No. 165,570 (Exhibit 40). Seymour vs. Osborne, 11 Wall, 516, 538.

It is also laid down as a proper rule of decision that when a device has gone into general use and has displaced other devices, which had previously been employed for analogous uses, this, though not necessarily establishing the patentability of the later device as being the result of invention, is always to be considered in deciding as to that point, and, when the other facts in the case leave the question in doubt, is sufficient to turn the scale.

Smith vs. Goodyear Dental Vulcanite Co.,
91 U. S., 486, 497.

The evidence in the present case shows that the entire metallic circuit for railroad signals has been generally given up as impracticable, and that while the Hall signals, with his ground circuit, is in full operation on many of the leading roads, the Pope system has never yet been applied on a single railway. Record, p. 105.

The Bianchi patent suggested the use of the earth not as an equalizer, but as a conductor, in a close circuit, where the passing train broke the circuit, drew away the armature from the signal magnet, and thus actuated the signal.

Defendant's Evidence, Record, p. 243.

The Pope patent is for an open circuit, where the passing train forms the circuit, draws the armature to the signal magnet, and so actuates the signal. The circuit in the Hall system is also an open one.

There is no evidence that any one ever thought of introducing the earth into the circuit, as an equalizer of resistances, for purposes of railroad signaling, until Snow did, on Feb. 14, 1874.

Its use in railroad telegraphy did not necessarily suggest its use in automatic railroad signaling. In addition to the fact

that Hall, the father of the art of railroad signaling by electricity in America, and who for nine years had given his whole time to its study and development (Defendant's Testimony, Record, p. 154), was occupied for two years, with a corps of able assistants, in experimenting to find out the very things which Pope left undescribed in his patent, we have the testimony of experts that, without similar experiments or new inventions, the Pope patent would remain a mere statement of an impracticable theory.

This is the language of

President Morton, Record, pp. 239, 250–252.
Thomas S. Hall, Record, p. 228.
George H. Snow, Record, p. 176–177.
Alvah W. Hall, Record, p. 154.

President Morton testifies (Record, p. 243, pp. 261–263) that there is a radical difference, shown in the very terms of the art, between the two wire conductors of the Pope patent and the single wire and earth return circuit of the Chelsea application (Exhibit C), since, in the latter, both our conductors carry the positive current in the same direction away from the battery, while only one of Pope's conductors does this, the other being always occupied in bringing the current back to the battery.

To state this difference in another way, the battery in the Pope combination must drive the electric fluid along the whole length of both the conductors C and Z; while by our system it is only to be driven over one—the metallic—conductor, till it meets the earth, thus taking only half the battery power.

See testimony of President Morton, Record, pp. 269–271.

Devices claimed to infringe a combination "are different, in the sense of the patent law, when they perform different functions, or in a different way, or produce a substantially different result." Machine Co. vs. Murphy, 97 U. S., 120, 125.

Again, the rule is that in a patent for certain means of producing a result, "the means described must be the essential and absolutely necessary means, and not mere adjuncts, which may be used or abandoned at pleasure."

Russell vs. Dodge, 93 U. S., 460, 462.

In the case cited, it was, therefore, held that a patent for treating leather with hot fat liquor was essentially different from its re-issue in the shape of a patent for treating leather with fat liquor, in the specification of which it was stated to be desirable to heat the liquor to or near the boiling point.

So when Mr. Pope expressly requires his return conductor to be "insulated from the earth," and thus definitely selects and describes a particular kind of circuit, from which the earth is excluded, he cannot be heard to complain that others have adopted a different kind of circuit, of which the earth is a necessary part, and use it in connection with a single battery to produce the result aimed at in his patent. Indeed in the very patent, No. 129,425, which is named in his assignment to the plaintiffs (Exhibit B, Complainants' Exhibits, p. 5) he excludes the earth from his circuit for the very reason that he thinks its use impracticable. In the specification of that patent, he says (Complainant's Exhibit O, p. 49):

"It will be observed that I do not make use of the earth as a part of the circuit in any of the hereinabove described arrangements of conductors, but that the circuit, exterior to the battery when completed, consists entirely and exclusively of a series of metallic conductors in every instance. I prefer this arrangement on account of the difficulty of securing an adequate insulation between the rails and the earth, when both earth and rails are included in and form part of the circuit."

3.

POPE'S CIRCUITS ARE NECESSARILY OF UNEQUAL, OURS OF EQUAL RESISTANCE.

Another material part of the Pope combination is the creation of several electric circuits of unequal resistance.

Throughout his specification, and drawing, and in each claim, the several circuits are unequal in length, and, therefore—since they are all wire—normally unequal in their resistance. To obviate this difficulty, he says some mode of adjusting these resistances should be resorted to, so "that they will be, as nearly as possible, equal to each other, as a much more perfect action of the apparatus will be secured thereby."

But, in our combination, we avoid this necessity of adjusting differences of resistance, by making—no matter how—all our circuits precisely equal in length, in the first instance. We eliminate from Pope's combination one of its costliest and most difficult parts—the equalization of resistances. We do by three steps, what he can only do by four. His circuits are always unequal, and requiring to be equalized; ours are always equal.

See testimony of President Morton, Record, p. 267, 268.

II.

Double use.

The patent of Mr. Pope, No. 140,536, is invalid, because it is for a mere double use.

The claim is threefold:—

1. The combination of one battery with several local circuits and magnets, to display a series of signals.

2. The combination of one battery with several local circuits and magnets, to release or conceal a series of signals.

3. The combination of one battery with one local circuit and magnet, to display one signal, and with another local circuit and magnet, to release or conceal the same signal.

It is a patent for a new combination of old devices.

Mr. Pope testifies as to this, on cross-examination, as follows:

"Prior to my patent a mode of operating a series of visible signals by electricity along a railroad track had been known and practiced. The mode of doing this was by the use of positive and negative conductors, which were the prolongation of the positive and negative poles of one or more batteries. There was no novelty in the use of an electro-magnet with an armature connecting with a signal, nor of closing the circuit by the wheels of a moving train of cars passing over the rails, nor in so arranging the apparatus that, simultaneously with the display of one signal, another should be reversed or concealed, nor in insulating successive sections of the track, so that a train of cars in passing along would operate to close a new circuit as it passed over each section."

Complainants' Testimony, Record, p. 15.

Mr. Farmer, the complainants' main expert, on his cross-examination, testified as follows:

"I do not recognize any single device of this patent, Exhibit A, as new. The only novelty is in its combination and arrangement. There is no novelty in arranging a single battery to operate, by the increase (?) of many conductors, many different signals at many different points. I consider that the novelty lies in arranging them along the side of a railroad so that each shall be operated by the passing locomotive, in the proper order of succession.

Cross-Int. 1. Was there, at the date of Pope's patent, any novelty in creating a number of subsidiary electric circuits, by connecting subsidiary wires with two main wires proceeding from one battery, as the prolongation of its positive and negative poles?

Ans. There was not; but I consider the novelty of the invention in so arranging the circuit closers and signals that they should be operated automatically by the passing trains in definite and predetermined succession."

Complainants' Testimony, Record, pp. 18, 19.

It appears also, from Complainants' Exhibit R (Complainants' Exhibits, p. 55), that the use of one battery to actuate a number of electro-magnets through an equal number of separate electric circuits, and thereby produce sounds from each magnet, had been long familiar in telegraphy, and publicly communicated to the world by Mr. Pope in a printed book as early as 1859. Of this arrangement of sounders, Mr. Farmer says:

"I remember to have seen such a system of operation in use in Boston; in the Western Union Office, to the best of my recollection several years prior to Complainants' patent. Exhibit A. It was used in the office of the Western Union Company as a means of working all their sounders from one local battery; those sounders being distributed in different parts of the building, and at different distances from the battery, at such different distances as made it, at least, desirable to equalize the resistances of these respective circuits."

Complainants' Testimony, Record, p. 114.

Mr. Farmer also testified in rebuttal, on cross-examination, that it would not involve the exercise of the inventive faculty, on the part of a competent electrician, familiar with Exhibit R, to construct the apparatus applied by Mr. Hall on the Eastern Railroad, Exhibit 8, and which differs from the combination claimed in the Pope patent, only in showing in detail a practicable mode of effecting what that patent indicates as its professed object.

Complainants' Testimony, Record, p. 140.

President Morton also testified, on cross-examination, that the arrangement of connections in this apparatus (Exhibit R), was substantially the same as in the complainant's sketch (Exhibit Q) of what they claimed to be their signaling system, as applied to a railroad line.

Defendant's Evidence, Record, pp. 265, 266.

Without stopping, as yet, to ascertain if the defendant's testimony has not shown a similar use of a single battery to actuate a series of railroad signals, long before the Pope patent, we ask, if on the plaintiff's own showing, their patent is not for a mere double use.

The end of the invention is the simplification of a well-known signaling apparatus by the use of a single battery instead of several batteries, "thereby obviating the inconvenience and expense of employing as heretofore, one or more separate batteries, situated at or near each signal, for the purpose of actuating the same."

Specification of patent: Complainants' Exhibits, p. 2.

We submit that this mere suggestion that one battery might be used to actuate a number of railroad signals, when every electrician knew that one battery could be used to actuate a number of electro-magnets by the use of as many subsidiary circuits, was not patentable. Mr. Pope did not, as did Messrs. Hall & Snow in their patent No. 165,570, give any particular description of how one battery could be used for this purpose. He merely claimed that one battery might be used in electric signaling on railroads, just as it had long been used in constructing electrical apparatus for other purposes.

"This was simply the application by the patentee of an old process to a new subject, without any exercise of the inventive faculty, and without the development of any idea which can be deemed new or original in the sense of the patent law. The thing was within the circle of what was well known before and belonged to the public. No one could lawfully appropriate it to himself and exclude others from using it in any usual way for any purpose to which it may be desired to apply it."

Brown vs. Piper, 91 U. S., 37, 41.

Mr. Pope's patent is like that for the application of a form of carriage wheels, in use on ordinary roads, to railway cars, which was declared void in *Losh vs. Hague*, or for the combina-

tion with a locomotive engine, of a swiveled truck, which had before been used on ordinary cars.

Pennsylvania R. R. Co. vs. Locomotive Truck Co., 110 U. S., 490, 494.

"It would be a very extraordinary thing to say that because all mankind have been accustomed to eat soup with a spoon, that a man could take out a patent because he says you might eat peas with a spoon. The law on this subject is this: that you cannot have a patent for applying a well-known thing which might be applied to 50,000 different purposes, for applying it to an operation which is exactly analogous to what was done before."

Losh vs. Hague, Webster's Pat. Cases, 202, 208.

It is the mere application of an old process and old machinery to a new use. It is precisely the same as if a coffee mill were now, for the first time, used to grind corn.

Howe vs. Abbott, 2 Story, 190; 2 Robb's Pat. Cases, 99, 103.

III.

Want of novelty in the Pope patent.

Our claim thus far has been that the Pope patent discloses nothing more than a new use of an old combination. But the defendant's evidence shows that the patent does not even disclose a new use. This particular use of the combination had been made long before, in substantially the same way.

In 1854 the English patent of Bianchi (Exhibit Bianchi. No. 42) described, in the words of President Morton,

"the use of a single battery, in combination of two or more instruments for interrupting and renewing electric connection, in combination also with two or more electro-magnets, actuating, or causing to be actuated, visible or audible signals, capable of attracting the attention of an engine-driver on a train."

Defendant's Evidence, Record p. 243.

Bianchi ran a wire conductor along the line of railway between two stations, and connected it by means of local circuits with a series of electro-magnets which he called interrupters, placed at intervals of a mile or less, along the line (p. 243). A battery was placed at each alternate station (pp. 243, 245), and the earth was used as the return conductor. The circuit was a close one (p. 243), to be broken, automatically, at each electro-magnet or interrupter, by the locomotive engine, in passing. This was accomplished by the depression of a lever, which was borne down by a roller attached to the locomotive (p. 244). As each interrupter was thus passed, and each local circuit broken, the armature of each magnet was drawn away by a spring (p. 244), and set a wheel in motion, which displayed a signal and rang a bell at the station (p. 244). The interruption of the circuit was momentary, and when re-established, the armature flew back to the magnet, thus leaving the signal free to drop or be silenced (p. 244).

Another use of this apparatus was to enable watchmen along the line to signal danger to the stations, or to approaching trains, by breaking the circuit, by depressing a button (p. 245), and thus displaying, simultaneously, danger signals, audible and visible at all the signal points.

Bianchi's third claim was

"The mode of combining the various apparatus heretofore described, and arranging them so as to be worked by one and the same galvanic battery, as heretofore described, in reference to Figure 12, Sheet II." (Record, p. 246.)

This is equivalent to the first claim of Pope's patent, No. 140,536, except that it is fuller and more specific. True, the arrangement of apparatus preferred by Bianchi was for a simultaneous display of several signals on the same block section of the track, and that of Pope was for the successive display of

single signals, on successive blocks, but this involved no difference in the principle of operation. Bianchi did, indeed, more than Pope. As his train rolled along, it displayed *many* signals on each section of the track traversed, while Pope's train only displayed one signal on each section. Bianchi did not claim in terms the combination of one battery with several signal instruments, by means of several circuits, for the special purpose of releasing or concealing the signals; and his interruptions of the circuit were only momentary, ceasing as the train passed on. He, however, says of his apparatus on page 176 of his patent,

"It may also be constructed so that two interruptions may display another signal, indicating one line of a double line of rails, and so arranged as to cover or hide the preceding signal. The signal men are thus warned to stop all trains on one or both lines."

The mode of doing this (by the aid of a signal man), is fully described on pp. 187, 188 of his patent. But the principle of the combination for displaying a number of signals, whether simultaneously or successively, along a railroad, by the passage of a train, is necessarily identical with that of a combination for dropping or concealing the same signals, by the same means. It requires no invention to make the armature of a magnet throw a lever to the right instead of the left, or to make it exert a force in closing on the magnet, instead of exerting it in flying apart from it.

"A mere carrying forward, or new, or more extended application of the original thought, a change only in form, proportions or degree, doing substantially the same thing in the same way, by substantially the same means, with better results, is not such an invention as will sustain a patent."

Roberts vs. Ryer, 91 U. S., 150.

In this last case, it appeared that one Lyman had invented

a refrigerator with a cold air chamber in which the air was cooled and dried, and from which a current circulated through the meat box, and refrigerated the meats, as it *ascended.*

Sanford, afterwards patented a refrigerator similarly constructed except that he refrigerated the meats by the current as it *descended*, and claimed the combination of the air chamber circulating device with the use of the descending current; and it was held that he took nothing by his patent.

Id., 157, 159.

It is not the object of the patent laws, "to grant a monopoly for every trifling device, every shadow of a shade of an idea, which would naturally and spontaneously occur to any skilled mechanic or operator in the ordinary process of manufactures."

Atlantic Works vs. Brady, 107 U. S. 192.
Phillips vs. Detroit, 111 U. S. 604, 608.

The British patents of Johnson, granted in 1858 (Exhibit M), and of Clark, granted in 1861 (Exhibit Clark, No. 44), did, in fact, carry forward Bianchi's invention, by causing the moving train, in displaying one (danger) signal to unlock and conceal another one, previously displayed, on a section of the track over which the train had already passed.

Defendant's Evidence, Record, p. 246.

Clark used a stationary battery, and Johnson placed his on the moving train. Complainant' Exhibits, p. 25.

Another device for the same purpose is described in the British patent granted to Barnes and Hancock in 1868 (Exhibit Hancock, No. 46.) Defendant's Evidence, Record, p. 248.

And another in the Warner & Odell patent, No. 130,776 (Exhibit No. 48).

The early patents and experimental applications of Mr. Hall, we will refer to hereafter.

In view of evidence of this character, President Morton testifies explicitly (Record, p. 252), that it did not involve the exercise of invention, at the date of Pope's application, to arrange the apparatus described in his patent.

IV.

Uncertainty and Inutility of the Pope Patent.

The complainants' patent is void for want of both certainty and utility. A patentee must put into his specification a written description of his invention,

"and of the manner and process of making, constructing, compounding, and using it, in such full, clear, concise and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use the same; and in case of a machine, he shall explain the principle thereof, and the *best* mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery." Rev. Stat., p. 954, sec. 4888.

"The degree of certainty, which the law requires, is set forth in the Act of Congress. The specification must be in such full, clear and exact terms, as to enable anyone skilled in the art to which it appertains, to compound and use the invention; that is to say, to compound and use it *without making any experiments of his own.*

Wood vs. Underhill, 5 How, 1, 4.

1.

It Describes no Signal Mechanism.

In the Pope patent there is no description of the signals to be used, except that

"said signals may be of any suitable construction, and should be provided with some suitable means of retaining them in position or action after the circuit through the magnets MM or M2 has been interrupted."

The only description of the reversing magnets is that they are "so arranged as to release, reverse or stop the action of said signals."

The general method theretofore used, of bringing a visual signal into action and keeping it displayed, had been by the interposition of a secondary battery: the circuit closed by the passing train had not itself actuated the signal magnet, but had actuated an intermediate magnet connected with a local battery, and this had established a secondary circuit acting on the armature of the signal magnet.

An ordinary electrician, therefore, would have been unable to construct the apparatus indicated in the patent in suit, except by the use of two batteries, one for the main line and one for each visual signal.

True, the specification expressly excludes the necessary use of more than one battery, but the trouble is that it does not indicate how otherwise you can get the signal "of any suitable construction," provided with "some suitable means" of overcoming the difficulty due to the interruption of the main circuit.

Mr. Pope says that the Johnson patent of 1858 (Exhibit M), describes the necessary signal mechanism. President Morton thinks otherwise.

Defendant's Evidence, Record, p. 255.

And the complainants' expert, Mr. Farmer, says that he has no recollection of having any knowledge of the existence of such a patent, until after this suit was brought.

Complainants' Testimony, Record, p. 137.

But whatever may be the efficacy of the mechanism of the Johnson patent, it required two batteries, one to actuate and one to retire the visual signal. Its third claim is for "the application and use of two combined electric batteries in such a manner that one shall complete the circuit of the other, as hereinbefore described" (Complainants' Exhibits, p. 28). So did Mr. Pope's previous application at Pittsburgh, and patent No. 130,941, of August 27, 1872 (Exhibit EE), require two batteries. The main battery actuated a relay and thus brought a secondary battery into play, which vitalized the signal magnet: then a branch circuit through the first battery released the signal. Complainants' Testimony, Record, p. 49.

Mr. Pope admits that the use of some mechanism equivalent to that covered by the Hendrickson patent No. 143,694 (Exhibit AA), for the purpose of retaining the signal in position or action, after the circuit which called it into action is broken, is "an essential element in the combination patented in Exhibit A"

Complainants' Testimony, Record, pp. 46, 99.

But if it is an essential element, it should obviously have been particularly pointed out as such.

It is certainly the office of the claims in a specification for a new combination of old elements, to describe every one of these elements which is essential, so that an expert will know at once what it is, and where it is to be found. Yet not one of the three claims in Exhibit A mentions the necessity of any signal mechanism for the purpose mentioned, or so much as refers to any as a possible element in the combination; still less is Hendrickson's or any other referred to or hinted at. This alone is fatal to the patent.

In the latter part of his testimony, Mr. Pope says that the

simple use of residual magnetism, without any lock or detent, would be a suitable means for retaining his signals in position after the actuating circuit had been broken.

Complainants' Testimony, Record, p. 99.

But this simply shows the more clearly the uncertainty of his specification, since it leaves the machinist, who is seeking to construct the apparatus described, without any intimation whether he must seek his "suitable means" of retaining the signal in position in the domain of electricity, or of mechanics.

2.

NO MODE OF EQUALIZING DISTANCES IS SHOWN.

Again, an entire metallic circuit is employed in the patent in suit and yet the only allusion to the difficulty arising from using the same battery power for the longest and the shortest circuit, is in the statement that

"The respective resistances of the several circuits should be so adjusted that they will be, as nearly as possible, equal to each other, as a much more perfect action of the apparatus will be secured thereby."

No particular description of the circuit-closers is attempted, except that they are insulated sections of the track. The specification leaves us to guess how long these sections should be, yet Mr. Pope in his testimony in rebuttal, says that one of the "essential elements" of the combination in his patent is "a circuit-closer, which when operated by a railroad train moving at any practicable rate of speed, will remain closed long enough for a signal disc to be moved into position by the action of an electro-magnet, even if the operation requires several seconds, as is the case when a small battery power is used."

Record, p. 46.

It cost Mr. Hall more than two years of experiment before he could adapt the proper signals and circuit-closers to the one battery system, and overcome the difficulty from the unequal resistances.

The adoption of the ground circuit seems a simple thing, now, but it was the result of costly and unsuccessful trials with the metallic circuit, which is an essential part of Pope's combination.

It was precisely the want of this mode of obviating the difficulty of unequal resistances, which has rendered vain all attempts to use in practice the other signal systems than those of Hall.

Mr. Farmer testified on cross-examination that he had never seen, in practice, a long line of electric railroad signals, successfully operated for any length of time, without making the earth serve as part of one of the main conductors.

Complainants' Testimony, Record, pp. 19, 20.

Mr. Farmer says:

"I would not recommend the substitution of a metallic conductor, in place of the earth, in precisely such an arrangement of circuits as I find in use on the Eastern railroad."

Complainants' Testimony, Record, p. 21.

And, in fact, the Pope system has never yet been put in actual operation on a single railroad, for a single hour.

Complainants' Testimony, Record, p. 105.

The Pope system, then, proves impracticable without the substitution of the earth for the wire conductor Z. His patent contains no suggestion of such a substitution, unless it be where it states that the resistances should be equalized. He admits the inherent defect in his metallic circuit, advises an

attempt to remedy it, and is silent as to how this attempt should be made.

In his testimony in rebuttal, Mr. Pope faintly claims that his one battery system could be worked successfully without resort to any mode of equalizing resistances, provided signal machines like Hendrickson's (Exhibit AA) were employed.

Complainants' Testimony, Record, p. 106.

In the same answer he admits that if, without the introduction of such mechanism, it was attempted to operate his signals wholly by the power of the battery, the system would not work, unless the resistances were equalized. He simply, therefore, flies from Scylla to Charybdis. You must either, he owns, equalize resistances, or use such a machine as requires a very slight current for its operation; but his specification is equally silent as to the mode of adopting either expedient.

3.

NO MODE OF INSULATING THE RAILS IS SHOWN.

Mr. Pope describes no mode of insulating the sections of the track, and President Morton tells us that it could not be successfully and permanently accomplished in actual practice.

Defendant's Evidence, Record, pp. 240, 258.

The answer given us to this is that the size of the rails makes them such good conductors that but little tension is required, or leakage possible. But the earth is bigger than the rails, and no insulation can long keep the two conductors apart. The views of President Morton as to this are confirmed by Mr. Pope's own book on the Modern Practice of the Electric Telegraph, where he lays down the very laws, the effect of which he now seeks to avoid.

Complainants' Testimony, Record, pp. 109, 110.

4.

POPE CANNOT CLAIM THE USE OF HALL'S INVENTIONS AS COMMON PROPERTY.

Mr. Pope attempts to support his patent by saying that, in the construction of the various parts of his combination, all those devices previously invented by Mr. Hall could be adopted; or, in his own words,

"I consider the defendants' inventions, so far as patented, in public use, or described in printed publications, to be thenceforth a part of the state of the art."

Complainants' Testimony, Record p. 73.

If he refers to Mr. Hall's arrangement of apparatus under his one battery system, on the track of the New York, New Haven & Hartford road at Meriden, in April, 1873, a month before Mr. Pope applied for the patent in suit, as amounting to a public use, we reply that it was not such, since, though what we did was done publicly, and exhibited to many railroad men, it was done simply as an illustrative and experimental application.

If, on the other hand, Mr. Pope means to refer to Mr. Hall's prior inventions, not connected with the one battery plan, we say that his specification, if he wished to take benefit from these, should at least describe which were suitable for use in his combination, by pointing out their nature or otherwise identifying them.

It would seem that the plaintiffs do claim that the Meriden application of December, 1872, or January, 1873, was a part of the state of the art on May 15, 1873, when the application for the patent in suit was filed, for they asked Mr. Farmer in substance if this patent displayed the exercise of invention, not-

withstanding the patentee was or ought to have been acquainted with this application, as represented by our Exhibits 5 and 6; and he replied that it did.

Complainants' Testimony, Record, pp. 112, 113.

But the proof is conclusive that what was shown at Meriden was shown simply for the benefit of the inventor, and without a thought of abandonment.

V.

The Plaintiffs not the Owners of the Patent sued on.

The plaintiffs have failed to prove their title to the patent, No. 140,536.

It appears to be still the property of Mr. Pope alone: the assignment proved being of No. 129,425.

The words in the assignment, descriptive of the subject of the patent, are equally applicable to either of the two patents owned by Mr. Pope; the month in which the patent assigned (July) was issued, is the same for both patents; and the only question is whether the fact that the day in July, and the year of the decade, expressed in the assignment, are those belonging to patent No. 140,536, can set aside the express reference to patent No. 129,425.

If the assignment does not, as it stands, convey No. 140,536, the appeal should be dismissed without further inquiry, for the complainants allege a joint right and are bound to prove it.

Jones vs. Quinnipiac Bank, 29 Conn. 25.

The rules in equity as well as at law, protect a defendant by restricting the plaintiff to proof of the allegations he has

seen fit to make. Mr. Pope might have joined the other plaintiffs, as equitable assignees of the patent, and his proof might then have supported his allegations. But the suit is, in fact, brought by a partnership as joint owners of the legal title, and leave to amend has never been sought, though this objection was taken when the assignment was introduced (Record, p. 15) as well as in argument in the Court below.

Mr. Pope's testimony that his object in executing the assignment was to assign the patent in suit, Exhibit A, (Record p. 15) is incompetent to enlarge or vary the written instrument on which the bill is founded.

VI.

Priority of the defendant's invention.

We have thus far argued that the Pope patent is intrinsically invalid, and that, were it valid, we have not infringed it.

We now proceed to examine the evidence on the point of priority of invention as between the plaintiffs and the defendant. Both have patents for their respective inventions, and the plaintiffs' patent is prior in date. Each has the *prima facie* presumption in his favor, that he has invented what he has patented.

Thomas S. Hall, in 1869, had in operation, on the New York and New Haven Railroad at Stamford, a signal apparatus (Exhibit 41) so far similar to the combination claimed in the Pope patent, that it operated over several circuits, by the use of one battery, by means of Hall's patent double-circuit instrument (Exhibit No. 3), to which was connected a secondary battery.

In this apparatus one battery was combined, by means of

several circuits, with several magnets and their armatures, so that to form one circuit would break another, and that an audible signal, rung by the passage of a train over one block section of the track, was silenced by the same train as it entered the next section.

Defendant's Evidence, Record, pp. 144, 178, 204, 226, 251, 291, 293.

In the fall of 1870 similar combinations (Exhibit 27) were set up by Mr. Hall, on the tracks of the Hartford and New Haven Railroad, near Cedar Hill, New Haven, and at Wallingford. Defendant's Evidence, Record, pp. 208, 211.

These inventions attracted great attention, and were soon applied on other roads.

Further improvements were made, and in the fall of 1871, Mr. Hall set up a complicated apparatus (Exhibit 2) in the Grand Central Depot, New York City, combining, in the words of President Morton,

"everything that is specified in the claims of complainants' patent, with the exception that the circuit-closing devices are collected together, and are not placed at intervals along the line of a railroad."

Defendant's Evidence, Record, p. 249.

This apparatus was so contrived by the use of the double-circuit instruments connected as above described, that one battery served to operate twenty-four circuit-closers with their appropriate magnets and signals; the circuits being closed or broken by a switchman, and the sounding of an audible signal, at one point on the track, calling attention to the simultaneous display of a visual signal at another and distant point.

Defendant's Evidence, Record, pp. 145–147, 155.

Three inside signals, in various rooms in the depot, were also automatically operated from the same battery.

Defendant's Evidence, Record, pp. 213–216.
Exhibit No. 34.

In the apparatus thus far contrived by Mr. Hall, for railroad lines, he had made use of a secondary battery as a convenient mechanism for use in connection with the double-circuit instrument. Defendant's Testimony, Record, p. 157.

In 1872, he determined to dispense with this secondary battery, and constructed a successful experimental apparatus for this purpose. About June, 1872, he told his son Alvah that he was engaged in perfecting this system (Defendant's Testimony, Record, p. 153), and on December 21st, 1872, he communicated a more particular description of his new plan to Charles H. Mansur, who set up the apparatus, a few days afterwards, in the New Haven workshop of the Electric R. R. Signal Co.

Defendant's Evidence (C. H. Mansur), Record, pp. 191, 194, 207, 281.
(T. S. Hall), Record, p. 221.
Exhibits Nos. 16 and 17.

A similar apparatus was set up in the shop at Meriden by Alvah W. Hall, in the latter part of December, and soon afterwards connected with the Hartford and New Haven railroad track.

Defendant's Evidence, Record, pp. 160, 163, 193, 222, 236.
Exhibits 5 and 6.
Exhibit L.

Mr. Farmer admitted, on his final cross-examination, that this first Meriden application in December, 1872, contained all there was of novelty in the one battery system.

Complainants' Testimony, Record, pp. 137, 138.

He says (p. 137) that the sketch of this application (Exhibit 6), indicates a practicable method of operating a number of Hall's double-circuit instruments, by the use of one battery, in a definite and predetermined succession (p. 137).

He also says (p. 138) that an expert familiar with Hall's double-circuit instruments, with Hall's original application on the Eastern railroad, under his old multiple battery system (Exhibit 36), and with the arrangement shown in Exhibit 6, could, without exercising any inventive faculty, construct the apparatus set up at Meriden in April, 1873 (Exhibit L), by which the instruments in the shop were connected with the track, and operated by passing trains.

He had formerly said (p. 121) that our first application on the Eastern road in December, 1873, of the one battery system, with an entire metallic circuit (Exhibit 10), was substantially the same as the system described in the patent in suit, and he now adds that this Exhibit 10 corresponded substantially in its scheme of operation to the Meriden track application (Exhibit L).

There can, therefore, be no real dispute that in December, 1872, we exhibited publicly in Meriden, the very thing for which, according to his own claims and evidence, Pope, in the May following, sought and obtained the patent in suit.

Mr. Hall's one battery invention was communicated to C. F. Hatch, the General Manager of the Eastern railroad, which we were then equipping, about the end of February, 1873, and the work there was stopped, until the new system could be substituted.

Defendant's Evidence, Record, pp. 159, 160.

Experiment showed that the change necessitated some alter-

ations in the apparatus, by which the circuits, when once formed by the track circuit-closers, should be maintained for a longer time than was requisite under the old system of several batteries; and also the addition of some device by which the visual signals could be kept displayed by mechanical means, instead of by a continuous current of electricity.

Defendant's Evidence, Record, pp. 164–166, 169, 170.

Nine months were spent in perfecting these changes, during which period, in September or October, 1873, an application for an English patent was prepared by Mr. Hall, in which the one battery system was described.

Defendant's Evidence, Record, p. 237.

In the improved apparatus constructed during this year, was included a device for a compensating rod, with a spring, in lieu of the former stiff rod of the visual signal, described in Hall's patent No. 150,030, applied for December 31, 1873, (Exhibit 11), and also a new form of circuit-closer contrived by Snow (Exhibit E).

In the specification of this patent No. 150,030, dated December 2, 1873, Mr. Hall says:

"From this description, it will be seen that one single battery serves to operate all the signals, whereby the cost of the apparatus and the expense of operating the same are materially reduced: and furthermore, by the combination of the safety signals with the danger signals, the system is rendered safe under all circumstances." Defendant's Exhibits, p. 103.

In his original application for this patent, Mr. Hall had included a claim for

"The combination of a series of signal-houses, arranged in pairs alongside of a railroad track with line wires which extend from one and the same battery, along the line of the road, and which connect with electro-magnets in the signal-houses, and with track-instruments, situated near the rails, substantially in the manner herein shown and described."

Complainants' Exhibits, p. 80.

This claim was rejected on the ground that it was anticipated by the Warner and Odell patents, of Aug. 30, 1872, No. 130,612 and 130,776, and by the patent in suit.

Mr. Hall preferred to wait, before insisting on the priority of his own invention of a one battery system, until he had practically tested the merits of his plan, by an actual application.

Referring to this, he says:

"The reason why I did not apply for patent No. 165,570 until June 15th, 1875, was the same reason that I have previously given in regard to my other improvements, which was to give a sufficient length of time for testing its practical utility, that I might become convinced that I should not require to make any further improvements, before making application for a patent."

Defendant's Evidence, Record, pp. 227, 228.

In November, 1873, he put up his apparatus for exhibition in the Lowell depot, in Boston, and in December, 1873, he made its first practical application, on the Eastern railroad.

It was soon found that though it worked well on short circuits, when extended for great distances along the line of a railroad, thereby necessarily forming circuits of unequal length, the amount of battery power necessary to work the longer circuits was excessive on the shorter ones, and fairly burnt off the wires.

Mr. Hall again set his inventive faculties to work, and on the suggestion of Snow, in February, 1874, substituted the earth for wire, as a return conductor. This completed the invention, for substance, but he preferred to continue his experiments and observations further, before taking out a patent, and from this cause, and on account of prolonged sickness, did

not apply for one until June, 1875. The application resulted in the Hall & Snow patent No. 165,570, of July 13, 1875 (Exhibit 40.) Defendant's Evidence, Record, p. 227.

If this patent is valid, the complainants have no case.

It is their claim that the first thought which led to the patent in suit, No. 140,536, occurred to Pope before Nov. 6th, 1872. He had taken out several patents for electric railroad signals prior to that time, and since his first introduction to the subject through Mr. Hall, but they seem to have proved of little value. The various kinds of apparatus thus patented, had been, or afterward were, applied on a number of railroads, but apparently only by way of experiment or advertisement. None of the plaintiffs can name any instance, up to the present time, in which they have been paid, for any such application, enough to cover the actual cost to them of putting it up. On the main application, on the Pennsylvania road, it is admitted that they received but half the cost.

Complainants' Testimony, Record, pp. 26, 27, 98, 100, 101, 102, 104.

The name of the corporation owning the Hall patents at this time was "The Electric Railway Signal Co." It took this name in 1870, and kept in active business under it, until November, 1873, when the defendant corporation was organized as its successor. Defendant's Evidence, Record, p. 203.

Upon the final retirement of Hendrickson from their employ in 1870, he seems to have thought proper to carry off with him their name as well as their inventions, and when the plaintiffs in the spring of 1871 set up their present connection, it was under the firm name of "The Electric Railroad Signal Co."

It was while a member of this firm, as the plaintiffs assert, that Mr. Pope in November, 1872, invented a plan for operating a series of signals by the use of but one battery, and described it on or before November 6th, 1872, to Stephen C. Hendrickson, who then made a pencil sketch of it (Exhibit X.)

Complainants' Testimony, Record, pp. 34, 52, 53.

This sketch indicates roughly an arrangement of wires in connection with one battery and two electro-magnets, but does not profess to show any apparatus by which the magnets could be actuated or a signal displayed, any form of signal or of circuit-closer, or any suggestion that the rails might or could be insulated or in any way be brought into the circuit.

Exhibits Y and Z, (the latter said to have been made and shown by Hendrickson to Mr. Pope on December 3, 1872,) are said to be designed to represent, not any system of signaling, but merely a signal machine operating by clockwork, Exhibit Y being the first rough sketch, and Exhibit Z a more detailed one, for which a patent was applied for December 26, 1872, and issued October 14, 1873, being No. 143,694. This apparatus was not especially adapted to use with one battery, and the patent made no reference to the one battery plan. Exhibit Y, Mr. Hendrickson, who drew it, says, is a "diagram of an improvement in the instrument or instruments, by which Mr. Pope's system was to be worked," and Exhibit Z was to represent "the perfected machine outlined in Exhibit Y."

Complainants' Testimony, Record, pp. 35, 53, 54.

In both Exhibits X and Y the cross-wires are represented as connected with one only of the main conductors, and no mode of forming a complete circuit is indicated. Mr. Hendrickson endeavored to help this out by testifying that cross-wires, running under a main wire, were generally represented,

in sketches of electrical apparatus, as terminating before they reached it; but his cross-examination will show how far this explanation can be supported.

Complainants' Testimony, Record, pp. 66, 68.

A patent was applied for by Mr. Pope, December 21, 1872' and granted March 31, 1874, No. 149,152 (Exhibit N), for "improvements in electric signaling apparatus for railroads," the object of which was

"to so arrange a series of semaphoric and audible signals, actuated by electro-magnetism at intervals along the line of a railroad, that each of the said signals will be automatically exhibited by the passage of a train, and will remain visible until the train is under the protection of the next succeeding signal when the first mentioned signal will be withdrawn, by which means one train following another upon the same track may be prevented from approaching too closely to the preceding train, or coming in collision with it. My invention consists in certain improved methods of combining and arranging the circuit-closers, wires, batteries, signals and signal mechanism, whereby greater efficiency and economy of operation are secured."

This patent contains twelve different claims, in which an earnest attempt is made to cover everything the patentee could think of, but not a word is said as to working the apparatus with one battery. On the other hand, the use of a secondary battery is expressly described and required.

If Mr. Pope had, prior to this, invented the one battery plan, it is passing strange that he did not include it in this patent, the only design of which was to secure "greater efficiency and economy of operation."

Complainants' Exhibits, pp. 29, 30.

And if Exhibit X is really, as Mr. Pope claims, the same thing as Exhibit A, why did he not, at once, stop his experiments in equipping the Pennsylvania and Lehigh Valley roads, on which he was at work in the winter of 1872-3, with this old system, and try this new and simpler one?

Mr. Hendrickson says that he generally put a date on all his sketches which he deemed new or important, when they were made. Yet he did not date any of these Exhibits, X, Y or Z. Exhibits X and Y have no date at all. The date on Exhibit Z is said to have been put on it by Mr. Pope, but at what time, whether before or after this suit was brought, it is not stated.

Complainants' Testimony, Record, pp. 35, 67, 68, 53, 31.

Hendrickson's diary, however, seems to indicate that Exhibit Y, at least, was made in January, 1873.

Complainants' Testimony, Record, pp. 67, 68.

The next person after Hendrickson, to whom Mr. Pope claims to have mentioned his plan for an apparatus for one battery, is Augustus G. Davis, of the Baltimore and Ohio Railroad, shortly prior to February 10, 1873. He does not say that he described the mode of effecting this, nor does Mr. Davis recollect anything about the nature of the plan, and the only result of the conversation was the erection of a single signal, which served only to illustrate the new signal-machine, but not any series of circuits and signals, operated by a single battery.

Complainants' Testimony, Record, pp. 54, 133, 135.

Mr. Pope, on cross-examination, admitted that this application did not illustrate the method of operating a series of signals from one battery.

"*Cross-Int.* 99. Did you subsequently make an application of your one-battery system on the Baltimore and Ohio Road?

"*Ans.* I did not, further than to put up one signal, which was done for the purpose of illustrating the action of the signal apparatus itself. I should perhaps say that the actual work of putting up this signal was done entirely by Mr. Hendrickson. I merely inspected it after it was done and in operation, to see that it was according to the plans.

"*Cross-Int.* 100. Did the signal in any way illustrate your one-battery system?

"*Ans.* It illustrated the operation of one signal in that system, but not that of two or more from one battery.

"*Cross-Int.* 107. Were you requested to put up this signal as a sample of your general system which had already been tested by use, or as a sample of your new and untried one-battery system?

"*Ans.* That I cannot say positively. I had previously been told by Mr. Davis that the multiple-battery system would not answer for their road." Record, pp. 103, 104.

What this mechanism put up on the Baltimore and Ohio Road was, Mr. Pope also fully described on p. 103:

"*Cross-Int.* 101. Was it anything more than one of your old signals, set up just as those signals had been set up, prior to your invention or conception of the one-battery system?

"*Ans.* The only difference was that the signal magnet was connected with the track circuit-closer. Prior to this, we had usually employed a relay and secondary battery for this purpose.

"*Cross-Int.* 105. Was not your object in omitting the relay, in putting up this signal, to show in its simplest form, on a short circuit, the operation of one of your signals by a passing train?

"*Ans.* That was the object."

Mr. Davis, indeed, testified on the direct examination, that the application embraced substantially the arrangement of the patent in suit, and consisted of sample signals covering a mile of road. (Record, p. 133.) On cross-examination, his recollection improved. He remembered that there was but one signal.

"The object was to show whether a train was on either of the three tracks or roads at their place" (p. 134).

"It was placed there as an experiment only, and it was found that the railroad company did not require such a signal at that point" (p. 134).

The next person to whom Mr. Pope claims to have explained his invention was Edwin D. McCracken, early in

April, 1873, and he says that Exhibit CC was made and given to McCracken at this time, April 10th, 1873. This plan does not contain any description or representation of the necessary circuit-closing apparatus or signals to be worked by the battery, and it is admitted that it does not show how any one-battery apparatus could be constructed.

Complainants' Testimony, Record, p. 104.

Mr. Pope also testified that McCracken represented himself to be in charge of Hall's apparatus on the Harlem Railroad.

Complainants' Testimony, Record, pp. 56, 57.

Mr. McCracken testifies as to this, that he never had any charge of the Hall apparatus, and that Mr. Pope never told him of any plan for working a signal apparatus with one battery, or gave him Exhibit CC, or any sketch of such a nature. He also says that he never had any conversation with Mr. Pope after January, 1873.

Defendant's Evidence, Record, pp. 285–288.

Mr. Pope also testifies that this apocryphal conversation with McCracken took place in the presence of and was participated in by Mr. Ashley (p. 56), but Mr. Ashley, though testifying that he was kept informed of the general nature of Pope's improvements (p. 24), has no recollection to offer of any such conversation.

On May 15th, 1873, Mr. Pope filed his application for the patent sued on, and was in such haste to do it that he did not wait to make any practical experiments to test the new combination in actual service.

Complainants' Testimony, Record, p. 57.

Up to May 15th, then, we have this as the history given by Mr. Pope of his invention; that he mentioned it to his co-plain-

tiffs, Hendrickson and Ashley, and to Davis and McCracken, between Nov. 6th, 1872, and April 10th, 1873, and that he never had put it to the test of experimental application.

Of the four witnesses thus called to attest the discovery, Ashley is silent, Davis recollects nothing of importance, and McCracken flatly contradicts him.

On the other hand, there is nothing to impugn any of the statements of Mr. Hall as to the priority of his invention. Having originally thought out the new plan at some time during the year 1872, he mentioned it to Charles H. Mansur early in December, and put it to the test of a practical application on Dec. 21, 1872, in the presence of Mansur, at New Haven, and a few days later, in the same month, by the aid of Alvah W. Hall, at West Meriden.

Defendant's Evidence: Thomas S. Hall, Record, p. 221.
Charles H. Mansur, pp. 193, 194.
Alvah W. Hall, p. 148.
George H. Snow, pp. 169, 170, 183.

This Meriden apparatus and application (Exhibits 5 and 6), was publicly exhibited.

Alvah W. Hall says (p. 149):

"My father showed them to a number of railroad men, as soon as completed, and took great delight in showing parties interested how he had overcome the difficulty of requiring a battery for each signal."

Thomas S. Hall (pp. 222, 224), names a number of these parties.

Alvah W. Hall (p. 166), does the same.

Among those thus named were Vice-President Reed of the New York, New Haven & Hartford railroad and Hon. O. H. Platt of the U. S. Senate. Had there been any question about the fact, the plaintiffs would have summoned them to contradict testimony so important.

The apparatus was connected with the railroad track, so as to be operated by passing trains, in March or April, 1873. See Exhibit L.

Defendant's Testimony: George H. Snow, pp. 170, 186, 190.
Thomas S. Hall, pp. 224, 236.
Alvah W. Hall, pp. 163, 167.

This, as the Court below has said, in its learned and exhaustive treatment of this branch of the case (Record p. 279–302), was something in which Hall developed his invention in wood and metal, made it useful and practicable, and achieved success, notwithstanding his subsequent experiments showed that, on a long circuit, the earth should be brought in as a return conductor.

It was admitted by Mr. Farmer (pp. 137, 138), the complainant's expert, that this Meriden application (Exhibit L) was substantially the same as our Eastern railroad application, next made, in December, 1873. (Exhibit 10).

The object of constructing it was to show in actual practice our one-battery system for actuating a series of signals, and it remained in position and action for six months, operated by all down trains.

See Defendants' Testimony, Record, pp. 224, 225, 235.

The signals were *displayed* by the trains, and *reversed* or concealed by depressing the lever of a model track circuit-

closer (Exhibit 38) by hand: but whether this lever was actuated by the hand, or by a train of cars, was obviously immaterial, when the trains in displaying the signals did act directly upon and through one full-size circuit-closer connected with the track. Indeed, this full-size circuit-closer was connected to the track, part of the time, in such a way as to *reverse* the signals.

Defendant's Evidence, Record, pp. 186, 190.

It is true that no series of signals was in fact set up in the shop, but Hall did set up on the wall as Mr. Snow testified, five

"double circuit instruments, like Exhibit C, and of the same size, which is full-sized instruments; by which I mean the full size that is used in practical signaling. *These instruments were to represent signals themselves*, as they used the momentary current, which it was thought necessary to use in working a number of signals on an open circuit, by one and the same battery." Record, pp. 170, 171.

It would have been an idle ceremony to attach visual signals to each of this row of circuit-closers on the wall of the shop, when any child could see that the movement of the armature, in the case of each, must operate any such attachment in the same way. The armature of each of the five was in fact operated by the train in definite and pre-determined succession, precisely as it would have been operated, had the signals been attached.

The moment that the first train operated the Meriden apparatus, we had a working invention, for a short circuit, reduced to actual practice, on a fair test. We were not bound to buy or hire a railroad to divide into "block" spaces, and on which we might compel the running of the trains by our signals.

Coffin *vs.* Ogden, 7 Blatchf., 61, 69, 70.

True, on a long circuit, we afterward found it desirable or necessary to use the earth as a return conductor, but this had not then been thought of by Mr. Pope, and was afterward thought of, first, by us. Mr. Pope, throughout his testimony, also, treated this use of the earth as no necessary part of the Hall system. He says, on p. 83:

"I do not consider that it would make any difference in the principle of the system by substituting one material for another for the return conductor; nor would it make any difference whatever in the practical results obtained. The difference would be merely in the first cost of construction of the additional metallic conductor, and the additional elements of battery required to produce the same effect through the additional resistance offered by the metallic conductor."

From the date of this Meriden application, Hall steadily worked at perfecting the mechanism for carrying out his one battery system till the Fall of 1873, when he began to equip the Eastern railroad with it. During the progress of this application, his superintendent of construction, Snow, thought of equalizing the resistances of the several circuits by using the earth as a return conductor, and wrote him (Exhibit H) of the success of the experiment on Feb. 14th, 1874. Snow had also in 1873 invented an air-cushion device for track circuit-closers, and the result of their joint thought and labor was their patent No. 165,570, of July 13th, 1875.

On November 15, 1873, also, printed invitations were sent out by Mr. Hall to an exhibition of his one battery system, at the Lowell Depot in Boston.

Record, Exhibits 12 and 13, pp. 280, 281.
Defendant's Evidence, Record, p. 171.

It thus appears that both Hall and Pope claim to have thought of the one battery plan in 1872, but that while Pope contented himself with a rude drawing or two, and mentioned

it to no one who now recollects the circumstance, except his co-plaintiff, Hendrickson, the discharged employee of Mr. Hall, Mr. Hall put his plan to experimental tests in December, 1872, and thereafter was continuously and openly engaged in perfecting and applying it, until Snow and he applied for their patent on June 23, 1875.

It further appears that from the date of his first alleged discovery to the present time, the Pope system has never been in a single instance actually applied to any railroad line. Mr. Pope testifies as to this, as follows:

Cross-Int. 116. When, if ever, did you first construct and put in practical operation an apparatus, such as is described in your patent, Exhibit A?

Ans. I have never constructed and put in practical operation on a railroad the combination described in that patent.

Complainants' Testimony, Record, p. 105.

In March, 1875, he substantially abandoned the subject of electric railroad signals, and has since given it no particular attention, except in the bringing and preparation of this suit.

Complainants' Testimony, Record, p. 104.

This question of diligence on the part of the two patentees is made a leading one by both pleadings and proof.

The answer (Record, p. 8), denies that Pope was the first inventor, says that Hall previously knew of the one-battery plan, and used it at Meriden, and (p. 8, fol. 19) "at the time the said patent was obtained by the said Pope, was using reasonable diligence in adapting and perfecting his, the said Hall's, said invention and discovery, and that the said Pope surreptitiously and unjustly obtained the said patent," by stealing the idea from Hall.

In the cross-examination of Mr. Pope, his attention was

particularly called to this question of his diligence in perfecting what he claimed to be his invention, as follows (Record, p. 104):

"*Cross-Int.* 115. When did you first construct and put to the test of actual experiment, an apparatus for actuating several signals by one and the same battery, in the manner which we have termed the one-battery system?

"*Ans.* I have never actually constructed and put in operation such a system, further than I have stated in my direct evidence, p. 63, fol. 249, 250, which was in October, 1872.* I speak of the system as a whole. The several parts of it had, most or all of them, been tested in practice before my application for a patent was made.

"*Cross-Int.* 116. When, if ever, did you first construct and put in practical operation an apparatus such as is described in your patent, Exhibit A?

"*Ans.* I have never constructed and put in practical operation on a railroad the combination described in that patent.

"*Cross-Int.* 117. Have you ever constructed and put in operation such an apparatus elsewhere than on a railroad?

"*Ans.* I constructed a working model of the whole apparatus, including the railroad and train in miniature, three or four years ago,† for the purpose of exhibiting and illustrating its practical operation, and this was so arranged that full-sized signals could be, and actually were, operated as a part of the combination.

"*Cross-Int.* 118. Where was that exhibited?

"*Ans.* It was set up in our shop in Center Street, in New York. I think we also had it at the office in Vesey Street, at one time, but am not certain about that.

"*Cross-Int.* 119. Is the combination described in your testimony on page 63, folios 249, 250, 251,‡ identical with the combination covered by your patent, Exhibit A?

"*Ans.* It is not."

His further cross-examination, on pp. 105–106, also resulted in a full admission that an apparatus such as is indicated in his patent, Exhibit A, could not be worked successfully in prac-

* This refers to his experiment with some apparatus in his office (Record, p. 52), which resulted in his patent of July 15, 1873, No. 140,790.

† As this testimony was given in March, 1879, the date of the model was as late as 1875 or 1876.

‡ This is the combination used in the office experiment in 1872, which led up to the patent of July 15, 1873, No. 140,790 (Record, p. 52).

tice without the addition of some device for equalizing the resistances.

Mr. Hendrickson was also improved as a witness to show the diligence of the plaintiffs in perfecting their invention.

On pages 34, 35 he says that he made, prior to Dec. 3, 1872, Exhibit Y, as a drawing of "an improvement in the instrument or instruments by which Mr. Pope's system was to be worked," and then Exhibit Z, as the "perfected machine, outlined in Exhibit Y."

The plan in Exhibit Y struck Mr. Pope favorably, and he had a working model of it (Exhibit A A) made, which "was tested and found to work admirably," and thereupon a patent for it was applied for (Record, p. 53), Dec. 26, 1872, and obtained under date of Oct. 14, 1873, No. 143,694. Pope was also giving his attention to still another projected patent for a new cut-off, etc., the application for which was filed Dec. 21, 1872. These inventions he put, at once, into actual use on several roads (Record, pp. 54, 55); but as to the patent in suit, he says (Record, p. 57):

"As the various parts of the combination, circuit-closers, signals, signal machinery, etc., had already been thoroughly tested in practice, and almost continually for over a year, it did not seem to me necessary to test the new combination in actual service before making an application for a patent, as it was a very easy matter for any competent electrician to calculate from existing data the amount of battery power, the size of conductors, and the proportionate electrical resistance of the different parts, so as to insure the satisfactory operation of the system in practice."

Indeed when seeking to explain his omission to allude to his one-battery system of circuits in the specification of patent No. 143,694, he says:

"I intended to take out a separate patent on this system of circuits *after I had had an opportunity to test it*, and therefore did not wish to make any disclosure of it in the specification of the patent of another inventor."

Record, p. 54.

If then we were to grant that Mr. Pope really thought out the one-battery system in November, 1872, of what importance is it, as the evidence stands? Mr. Hall also thought it out in 1872 (Record, p. 221), but he also proceeded in April, 1873, to work it out into form, and put it to the test of actual use on a railroad by railroad trains. Mr. Pope never put his thought into a tangible form.

Our invention was put in working shape and publicly exhibited in April, 1873, a month before Mr. Pope (on May 15, 1873) applied for his patent. The moment we proved this fact, whatever burden of proof as to priority his prior patent had given to him, shifted. He was now bound to assume the burden of proving an invention before April, 1873, and indeed before Dec. 21, 1872 (Record, pp. 194, 207, 281). This date of Dec. 21, 1872, is established in the most satisfactory manner by the testimony and correspondence of Mr. Mansur, as one on which Mr. Hall told him "that he had a plan whereby he could work a series of signals from New York to Boston by one battery." Record, p. 194 (* 301). He recollects that it was "on that day he requested me to write to G. W. Davis & Co., in regard to an engine, and we talked in relation to the engine." Record, p. 194 (* 301). He wrote and received a reply from G. W. Davis & Co., Exhibit No. 25, Record, p. 281. On re-examination, he is asked,

"*Re-E.* 86. Does that letter enable you to fix any more definitely the date of that conversation which you had with Mr. Hall, in which the one-battery system was first suggested to you by him?

Ans. It does. The conversation was held on Saturday,

which was the 21st day of December, 1872, late in the afternoon, and as I wished to write a friendly letter as well as a business letter to Mr. Rollins, the member of the firm to whom the letter was directed, I did not write the letter until Sunday, and dated it Monday, the 23d."

Record, pp. 207, 208.

The reply to the letter above described is as follows. (Record, p. 281, Exhibit 25.)

[Envelope].

Postmarked:
Nashua, N. H., Dec. 26.

CHAS. H. MANSUR,
No. 25 Whitney Ave.,
New Haven, Conn.

[Letter].

GEO. W. DAVIS & CO.,

Manufacturers of the patent automatic cut-off, stationary steam engines, portable engines, machinists' tools, shafting, pulleys and hangings with self-oiling boxes, and boring machines for boring stationary and locomotive steam cylinders, without moving them from the frame or bed.

NASHUA, N. H., Dec. 26th, 1872.

"*Friend Mansur*—Your favor of the 23d is rec'd. I was thinking about you a few days ago and wondering where you could be. I am glad to hear you are prospering. Our business is very good. We are making engines and planers.

We do not know that we can sell a 15 H. P. cut-off engine, any less than Corliss, but we think our 15 H. P. works better than Corliss.

We will deliver on the cars here an 8x24 in. cut-off engine, fly wheel 72x12 in., for $1,300. Will furnish a force pump and driving work for $60, and a heater for $40.

This size we call 17 H. P., and is the smallest we make. We can furnish a good second hand slide valve, 8x16 in. engine, in perfect order, for $550,—pump and heater same as above.

My family are in usual health.

Miss Celia is not married yet, but the prospect is fair for that event happening some time. I suppose you have some children, but you say nothing about them.

Hope you will put your best stock in and have good sound ones, and have them *often*.

Yours, very truly,

GEO. A. ROLLINS."

The date and postmark of a personal letter like this is worth a dozen witnesses, in fixing the time now in question. It showed that Mr. Hall began to speak of his invention as early as December 21, 1872. Mr. Pope was now bound, to save his patent, to show his own priority "by proof clear, positive, and unequivocal."

Thayer vs. Hart, 20 Fed. Rep. 693.

He attempts to show it, but it is largely by his own testimony, and without any claim of putting his idea to any test of practical experiment.

Which is entitled to the protection of the patent law, the inventor who spends patient years in testing the working of his system, and remedying every defect suggested by experience, until he is finally enabled to state in his specification the exact mode of constructing the necessary apparatus, or the theorist who hurries forward his application before ever once putting it to the trial of a practical application, and without being able to suggest any plan for equalizing the resistances of the circuits, which, unless equalized otherwise than by a difference of wires, would make the combination valueless?

"The settled rule of law is, that whoever first perfects a machine is entitled to the patent, and is the real inventor, although others may have previously had the idea, and made some experiments towards putting it in practice. He is the inventor, and is entitled to the patent, who first brought the machine to perfection and made it capable of useful operation."

Agawam Co. vs. Jordan, 7 Wall, 583, 602.

We may well use, with regard to Mr. Pope's invention, as it was at the stage when Mr. Hall's had been proved a success by actual experiment, the language of this Court when the *Coffin* lock case, already cited, came here on appeal:

"If the thing were embryotic or inchoate; if it rested in speculation or experiment; if the process pursued for its development had failed to reach the point of consummation, it cannot avail to defeat a patent founded upon a discovery or invention which was completed, while in the other case there was only progress, however near the progress may have approximated to the end in view. The law requires not conjecture, but certainty. If the question relate to a machine, the conception must have been clothed in substantial forms, which demonstrate at once its practical efficacy and utility. . . . Until his work is *done*, the inventor has given nothing to the public."

Coffin vs. Ogden, 18 Wall, 120, 124.

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